A.R.S. 3-45

SCIENTIFIC REPORTS

OF THE

IMPERIAL ENTOMOLOGICAL INSTITUTE
29 OCT 1946

Imperial Agricultural Research Institute, New Delhi

For the year ended 30th June, 1945

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI
PRINTED AT THE FEROZ PRINTING WORKS, LAHORE.
1946

R31/1043.

TABLE OF CONTENTS

		Page.
A.	Report of the Director—	
	I.—Introductory	1
	II.—Research & Investigations	2
	III.—General Administration	15
	IV.—Accounts	16
B.	Report of Imperial Agriculturist—	
	I.—Agronomy	
	Agricultural Research Institute, New Delhi	19
	Agricultural Sub-station, Karnal	28
	II.—Cattle Breeding	
	Delhi & Karnal	31
	III.—Research Programme for the years	
	1945-46 and 1946-47	33
	IV.—Statistical Branch	36
C.	Report of the Imperial Economic Botanist—	
	I.—Research	39
	II.—Crop outturns and seed distribution	46
	III.—Advisory	46
	IV.—Programme of work for 1945-46 and 1946-47	46
D.	Report of the Sugarcane Expert—	
	I.—Introduction	47
	II.—Sugarcane Breeding	47
	III.—The Genus Saccharum and Allied Genera	49
	IV.—Investigations	50
	V.—Sugarcane Sub-station, Karnal	51
	VI.—Distribution	52
	VII.—New Coimbatore Sowings	52
	VIII.—Programme of Work for 1945-46	53
E.	Report of Imperial Agricultural Chemist—	
	I.—Introduction	54
	II.—Soil Studies	54
	III.—Agronomical Studies	56
	IV.—Micro-biological Studies	60
	V.—Biochemical Studies	61
	VI.—Routine and Advisory	64
	VII.—Programme for the year 1945-46 and 1946-47	64

TABLE OF CONTENTS—(*contd.*)

	Page.
F. Report of the Imperial Mycologist—	
I.—Diseases of plants	66
II.—Industrial Mycology	70
III.—Taxonomy	70
IV.—Advisory	71
V.—Indian Type Culture Collection of Fungi	71
VI.—Herbarium	71
VII.—Programme for the year 1945-47	71
G. Report of the Imperial Entomologist—	
I.—Report on Investigations	73
II.—Advisory Work	78
III.—Programme for two years 1945-47	78
H. Report of the Director of Locust Control—	
I.—General	80
II.—Swarm Invasion	80
III.—Locust Activities outside India	82
Appendix I.—Gazetted staff of the Institute	83
Appendix II.—Training of students & Research Workers	86
Appendix III.—Publications issued during 1944-45	90

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Imperial Agricultural Research Institute, New Delhi for the year ended 30th June, '45

REPORT OF THE DIRECTOR

HEM SINGH PRUTHI, M.SC., P.H.D., SC.D.(CANTAB.), F.R.A.S.B., F.N.I.

I. INTRODUCTORY

The work of the Institute during the year is described in the accompanying reports of the different sections of the Institute and they record steady progress. A special feature during the year was the preparation of detailed plans for the expansion of the teaching and research activities of the Institute during the five-year period immediately following. The proposals for teaching were sanctioned from July, 1945.

His Excellency Field Marshal the Right Hon'ble Viscount Wavell, Viceroy and Governor-General of India, visited the Institute on Saturday the 24th February, 1945, in company of the Hon'ble Sardar Sir Jogendra Singh, Member in Charge of the Agriculture Portfolio of the Viceroy's Executive Council, Sir Pheroze Kharegat, Additional Secretary in the Department of Education, Health and Lands, and Mr. H. R. Stewart, Vice-Chairman, Imperial Council of Agricultural Research, and inspected the various activities of the Institute.

His Excellency's tour commenced at the Linlithgow Library which is the central building of the Institute. The distinguished visitor and the party accompanying him were next conducted by Dr. Hem Singh Pruthi, Director of the Institute, to the Cattle Breeding Section where on view was the famous Sahiwal pedigree herd has been developed from an average yield of 5 lb. per head per day to over 21 lb. per head per day, a standard of production comparable to that of European breeds. After inspecting on their way plots which demonstrated the advantages of manuring with phosphates a leguminous fodder crop, as well as successful use of monsoon rain water for ensuring both *kharif* and *rabi* crops, His Excellency visited the Botany Section where were exhibited specimens of the Institute's two outstanding achievements in plant-breeding, viz., Pusa wheats and Coimbatore canes. The more recent success of the Institute's Entomological Staff in fighting the Locust menace, not only in India but in the Middle East as well, was explained in the Entomological Laboratory where also were shown improved methods of storage of grains. After crop pests, diseases of sugarcane for which control methods are being evolved and other plant diseases, prominent among which are the virus diseases of potatoes, were brought to His Excellency's notice.

After examining specimens of rubber prepared in the Laboratory of the Institute from a flowering creeper called *Cryptostegia grandiflora* which can grow much quicker than Hevea and is not so selective as the latter as regards habitat and climate, His Excellency left the Institute.

II. RESEARCH AND INVESTIGATIONS.

1. Agronomy and Cattle Breeding

(a) *Agronomy*

Manurial experiments.—The old series of experiment to compare the relative value of nitrogen in green manure, farmyard manure compost oil cake and sulphate of ammonia which was started at the suggestion of Sir John Russell in 1941-42 was repeated, but the doses of manures were doubled in all treatments, excepting in treatment K, where the dose of farmyard manure was increased from 60 to 80 lb. nitrogen per acre. Alternate blocks in this series were further treated with the minor elements, boron and managanese in addition to the other manures. The stand as well as the final yields of wheat, I.P. 165 were very satisfactory and there was very little lodging in this field. Although the differential response to the manures was not statistically significant, due to the high value of the experimental error, increases in the yield of grain ranging from 188.5 to 421.0 lb. per acre were obtained from the manurial treatments over the "no manure" yield of 1932.4 lb. per acre. At a dose of 40 lb. nitrogen per acre, rape cake and activated sludge proved efficient in this series than leaf compost and farmyard manure. Almost the same position was retained by these four organic manures when they are supplemented with superphosphate at 40 lb. P_2O_5 and sulphate of potash at 40 lb. K_2O per acre, although the yields of grain were somewhat lower than those obtained when the organic manures were applied alone, except in the case of leaf compost. With sulphate of ammonia at 20 lb. nitrogen and superphosphate to make up 40 lb. P_2O_5 per acre in the mixture, leaf compost at 20 lb. N showed an increase of 20.70 and 14.25 per cent in grain and straw whereas farmyard manure with these fertilisers at the same dose, as in the above mentioned treatment, produced an increase of 18.78 and 16.73 per cent in grain and straw. The effect of the minor elements, boron and manganese was to decrease the yields of grain and it is proposed to study the cause of this in greater detail next year.

Owing to the high values of the experimental error which have ruled in this experiment since it was started, due to high soil variation, it was decided to start a new series in another field and the manurial treatments included green manuring with sannhemp and cowpeas and manuring with rape cake, castor cake, farmyard manure, leaf compost and sulphate of ammonia on the basis of 40 lb. nitrogen per acre. In the manured plots wheat I.P. 165 showed excellent growth but the heavy crops in these plots and especially that in the sulphate of ammonia treatment lodged badly. High yields of grain and straw were obtained, but the results were masked by the effects of lodging and by the incidence of rust in the lodged plots.

The work on the relationship of phosphates to legumes in regard to (1) increase in the yield of the legume, (2) increase in the phosphate and calcium contents of these crops, (3) increase in the yields of cereals following the manured legumes, (4) increase in nitrogen and phosphate content of the cereals

and (5) the role of phosphate manuring of legumes in developing soil fertility was confirmed and now constitutes one of the major lines of investigation in the Agricultural Section.

A number of other experiments in which phosphates were used showed the general trend that increasing doses of phosphates, particularly superphosphate, not only increased yields of berseem to which they were applied but also of unmanured wheat following berseem.

Experiments on the manuring values of ammonium nitrate alone in combination with 1, 2 and 3% T.N.T. were conducted at the suggestion of the War Department in order to assess the mineral values of those substances, large quantities of which are likely to be available after the war. Trials with paddy and sugarcane were taken up at Karnal and with sorghum, cotton and wheat at New Delhi. Although the ammonium nitrate and its mixtures with T.N.T. showed no differential response the yield of crops from these treatments were not significantly different from those obtained from the sulphate of ammonia treatment indicating that ammonium nitrate as well as its mixtures with T.N.T. had no harmful effects and could be used like sulphate of ammonia as efficient nitrogenous manures.

Experiments on the manurial values of Oklanite, digested and activated sludge in comparison with those of other organic manures and fertilisers were started during the year at the instance of the Government of India. The yield of peas, I.P. 29 from the 'no manure' plots was 19.9 maunds per acre and those from Oklanite, digested sludge, activated sludge and superphosphate at 80 lb. P_2O_5 per acre were, 18.8, 18.6, 20.2 and 21.1 maunds per acre respectively. In the case of barley, however, the yields of grain were 24.7, 37.2, 34.5, 33.6 from the 'no manure' oklanite, digested and activated sludge treatments at the same dose as applied to peas, but 39.4 maunds per acre from sulphate of ammonia at 80 lb. N. This suggests that the organic manures when applied late do not respond as efficiently as the mineral fertiliser in Delhi soils. This is further confirmed by another experiment which was laid out in a soil of poor fertility and in which I.P. 165 was sown after a heavy crop of sorghum. The yields of wheat grain from the 'no manure' Oklanite, digested sludge, activated sludge and H.A.F. (Prepared by the Sci. & Indus. Res. Lab. Delhi) were 12.3, 12.5 11.9, 13.1 and 11.6 maunds per acre respectively, the yields from the artificial fertilisers, sulphate of ammonia, Amatol and ammonium nitrate with 2% and with 3% T.N.T. were 28.2, 25.5, 18.0 and 30 maunds per acre approximately. The results indicate the value of a readily available fertiliser in late sown crops in a depleted soil at Delhi.

The results of the experiments with leguminous and non-leguminous green manure crops, with and without artificial fertilisers confirm the previous findings that the leguminous crops, sannhemp and cowpeas are more effective than the non-leguminous crops, maize and sorghum in producing higher yields of both grain and straw of wheat and that green manuring with sorghum invariably depresses the yields to a level even lower than from the 'no manure' control. This year sulphate of ammonia has had slighly better effect than superphosphate both with leguminous as well as non-leguminous green manures on the yields.

To a field green-manured with sannhemp, artificial fertilisers were applied. The yields of wheat I.P. 4 from the green-manure alone, sulphate of ammonia at 40 lb. N. and superphosphate at 80 lb. P_2O_5 treatments were 14.2, 14.7 and

15.3 maunds per acre, whereas those from the plots manured with a mixture these fertilisers at 40 lb. N + 80 lb. P_2O_5 averaged 20.9 maunds and the addition of sulphate of potash to this mixture at 50 lb. K_2O produced a yield of 20.8 maunds per acre.

Flood water farming experiments.—These experiments were repeated both at Delhi and Karnal. Due to good and well distributed monsoon rains and their extending up to October, flooding the land in August and September only did not show increased outturns of crops this year. In fact, the yields of the those crops were higher in the rainfed series than in the flooded series. This seems to be due to the loss of some nitrogen by the irrigations given late in the season, when only partial recovery of this nutrient is possible. In the case of oilseeds such as *sarson, toria,* tarumira and linseed increases extending up to 5 maunds per acre were obtained from the flooded series over the rainfed series.

Cultivation Experiments.—In cultivation experiments at Karnal, ploughing with Victory plough supplemented with country ploughs gave higher yields of wheat I.P. 165 than ploughing with tractor ploughs, whereas the lowest yields were obtained from the plots ploughed with country ploughs only. Yields from the plots manured with farm yard manure and with sulphate of ammonia, each at 40 lb. N per acre were similar, but those from fields manured with a combination of those two manures at a total dose of 60 lb. N were decidedly superior in all the cultivation treatments.

(b) *Cattle Breeding.*

At the end of the year the strength of the Sahiwal herd at Delhi was 291 head and that of the Tharparker herd at Karnal was 308 head. The daily average milk yield for the year for the former was 20.4 lb. and of the latter 20.17 lb. The daily average yield was 14.9 lb. in the Sahiwal and 13.6 in the Tharparker. The percentage of cows in milk was 72.9 in the former and 67.1 in the latter.

Early maturity experiments.—The long term experiments on early-maturity handling, weaning, and 4-times milking were continued both at Delhi and Karnal. In the Sahiwal herd 37 heifers at an average early age of 1 year 7 months and 12 days were bred to bulls on an average live weight of 627 lb. The average age of calving of 21 heifers which completed lactation during the year was 2 years and 4 months with an average calving weight of 834 lb. Their average lactation yield was 4999 lb. in 282 days. The daily rates of gain of these early maturity heifers at service age, calving age and closing lactation age were 1.1 lb., 0.91 lb., and 0.71 lb. respectively.

Calf rearing on standardised milk and sex ratios.—At Delhi the calves were weaned and reared on milk standrdised to 3.5 per cent fat and showed a much greater growth than those of the previous year which were also fed on the same system. The sex ratios of calves born was 63.3 per cent males and 36.7 per cent females with an average birth weight of 54 lb. for males and 52 lb. for females.

The Tharparker calves at Karnal were also weaned and reared on standardised milk.

The offspring of Tharparker bulls Pathan, Hakim, Jung and Bulwant have been predominantly males, whereas those of bulls Faisal, Tika, Ezaz and Sikandar have been predominantly females; Alum and Inum have given equal numbers of male and female calves.

2. Crop Improvement

(a) *Crops other than sugarcane*

Wheat Studies.—The study of the all-India collection of wheats was continued with a view to confirming the previous years' observations and thirtyfive wheats were added to the collection. The comparative study of 200 wheats grown at Delhi, Pusa and Coimbatore was continued while at Simla, the study of hill wheats was also continued. The varieties of wheat under study for registration were grown and described in great detail with a view to finally confirming the previous observations.

The F_5 generation of the intergeneric crosses, *T. vulgara* X *Secale cereale* and *T. vulgare* X *Aegilops caudata* was studied and promising plants possessing valuable characters, like high tillering, long ears, amber and red-coloured well-filled grains and high resistance to rusts were isolated and selected. In some of the F generation progenies of the cross *T. vulgara* X *Ae. caudata*, a few plants resembling *T. sphaerococcum* were noticed. Such plants were also observed to occur during the previous year in some of the F_4 progenies of this cross. These observations are interesting from the point of view of the origin of *T. sphaerococcum*. The study of the mode of inheritance of the branched ear, the "extra-glume" and the colour of glumes was continued in the crosses of *T. vavilovi* with *T.vulgara* and with *T. sphaerococcum*.

The testing of varieties, including new strains of hybrid origin, for resistance to loose smut, was continued. As in the last year, quite a large number of the new strains proved to be resistant. Work on rust-resistant wheats for the hills was carried out in collaboration with Dr. K. C. Mehta. Tests of varieties and hybrids for both seedling and adult resistance were carried out at Simla, and for adult resistance only, at New Delhi. Most of the hybrids from the brown and yellow rust crosses, now in the F_{10} generation, are pure for resistance to these rusts, thus confirming the previous years' results. The two black rust crosses were in the F_6 generation; although still segregating, some of the cultures are now nearly pure for resistance to this rust. Nearly 2000 plants from the double cross made last year to unite resistance to all the three rusts were tested for resistance in both the seedling and the adult stages.

Potato Breeding.—The study of commercial varieties of *Solanum tuberosum* from India and abroad, and of species of *Solanum* from South and Central was continued to elicit the range of characters available for breeding work. Progenies including F_1 and back-cross generations of crosses between *S. tuberosum* and *S. andigenum, S. demissum, S. Rybinii* and *S. curtilobum* and a number of inter-varietal hybrids were further grown and studied for selecting hybrids resistant to blight, viruses and frost. The trials of new hybrids evolved at Simla were continued at a number of hill stations in the Provinces and the States. Some of the hybrids tried at Bhowali (U.P.) Darjeeling (Bengal), Murree (Punjab) and Nanjanad (Madras) have given very encouraging results. At Shillong one of the Simla hybrids was under multiplication for general distribution. A new method of raising plants from sprouts was evolved and its practical implications were under study.

Disease resistance studies.—In pigeon peas the work of testing and selecting wilt-resistant strains from among the progenies of the cross I.P. 24 X I.P. 51 was further continued at Delhi and Pusa.

The selection of linseed strains resistant to linseed rust (*Melampsora lini*) was continued at Delhi and Karnal. While the incidence of rust was negligible at Karnal during the year under report, that at Delhi was again heavy. Here, only 4 out of 110 rust-resistant cultures were slightly infected, the others as well as the resistant exotic parent were free from the disease; all the I.P. types and other cultures were affected to varying degrees.

The collection of Nicotiana species was again grown at Delhi, Pusa and Guntur to test their reaction to *Orobanche*. The previous year's observation viz., that although all the species were attacked by the parasite some withstood the attack better than others, was confirmed.

Cytogenetical studies.—The large number of types of the cultivated *Brassicae* collected from all over India, were again studied from the morphological, genetical and cytological standpoints. A number of varieties brought from China were also grown and studied. Studies on the experimentally-synthesised *B. juncea* were continued from the point of view of their variability, sterility and crossability. The apetalous character was confirmed to be controlled by a single recessive gene subject to the influence of modifiers. Crosses between tetraploid forms of apetalous and petalled plants were also under study. The inheritance of the mucilaginous character of the seed coat was also under study in a cross between the apetalous mutant (brown-seeded. mucilaginous) x yellow sarson (yellow seeded, non-mucilaginous). It was found in the F_2 that mucilage was recessive to no mucilage and yellow seed to brown seed, each on a monogenic basis. When the two characters were taken together, it was observed that the combination yellow seed coat and mucilage was absent in the F_2 although the combination brown seed and no mucilage, and the parental combinations were obtained; further studies are in progress. Studies on the mode of occurrence of apomixis in both self-fertile and self-sterile species of *Brassica* were continued.

Large populations of the colchicine-induced tetraploids of *B. nigra, B. campestris* (*toria* and *sarson*), *B. tournefortii* and *Eruca sativa* (taramira) were grown and studied with regard to growth, vigour, morphological characters, cytological behaviour, fertility and crossability as compared to the corresponding diploids. Promising plants with increased fertility and vigour were selected.

Autopolyploids of various crop plants were under study in different generations with a view to evaluating their usefulness for breeding purposes. The C_7 generation of the tetraploids in gram (*Cicer arietinum* L), and chilli (*Capsicum annuum* L.) and the C_3 generation of *Sesamum orientale* were grown and studied with regard to growth vigour, fertility and other economic characters in comparison with their corresponding diploids and promising plants were selected. Selection for improved fertility through seven generations in the case of gram and chilli has not proved to be affective. The tetraploid *S. orientale* was found to be as efficient as its diploid as regards growth, branching and the number of capsules per plant, but the capsules yielded a very small percentage of viable seeds. Crossability between diploid and tetraploid forms of *S. orientale* in relation to growth of pollen tube in the stylar tissue and development of the embryo was studied.

Besides the autopolyploids, the amphidiploids of *Sesamum Nicotiana* were also studied. A large number of A_3 progenies of the amphidiploid, *S. indicatum*, was grown and studied with regard to their morphology, cytology

and fertility. The progenies were found to be fairly uniform morphologically but were pollensterile to varying degrees in spite of regular meiosis in them. They were highly female fertile under conditions of open pollination, but produced, besides some viable seeds, varying percentages of 'developed ovules' containing no embryo within. The cause of occurence of the developed ovules is under study.

Physiological studies.—These studies were continued using seven species of wheat. The following tentative conclusions could be drawn:—(i) All the species of wheat under study were not adversely affected by drought at the tiller initiation stage. The wilted plants revived from the effect of drought remarkably well and gave as good a growth and yield as the fully watered plants and in some cases gave even a better performance than the latter. These results confirm the findings of the previous year. (ii) Wilting at the shooting stage, on the other hand, reduced growth and yield of the different species to varying degrees; the later the flowering the greater was the damage due to drought. so much so that in the very late *Triticum monococcum* even earing was considerably retarded and practically no grain was formed. (iii) Plants from pretreated seeds recovered from drought much more quickly than those from untreated ones. (iv) Correlation between drought and phasic development was observed.

A complex experiment involving two temperature treatments three light treatments and twelve varieties belonging to nine different species of wheat (which included the seven species used for the drought experiment) was also carried out.

(b) *Sugarcane*

The season was quite favourable for flowering at the Coimbatore Sugarcane Station and a large number of crosses was affected. One of the important parents in the bulk crosses was Co. 301 which contributes non-pithiness to its progeny. A useful parent for introducing vigour in the seedlings which is now being used at Coimbatore is G. 1051—a seedling of the Burma form of *S. spontaneum*. Eight varieties of sweet sorghums have been utilised in breeding. One of these sorghum varieties has over 13% sucrose in the stalks.

The cyto-genetic studies indicate that in the crosses between different varieties of *S. officinarum* it is likely that the haploid genom may have unfavourable recessive genes for viability. The viability experiments on sugarcane pollen show that though it remains viable for more than a month, its actual fertilizing capacity is limited to three days from the date of collection. The physiological studies have shown that the soluble nitrogen remains low in the non-flowering varieties. With the aid of photoperiodism experiments the non-flowering variety *S. spontaneum* (Burma form) has again been made to flower this year.

The present delimitation of the genus *Saccharum* from allied genera is not considered to be a lasting one as several features of this group stand in need of detailed study. India is quite rich in the various forms of Saccharum and allied genera and it is proposed to organize an expedition for assembling these forms for intensive study as also for assessing their value as breeding material at Coimbatore.

3. Soils, Fertilizer and Plant Nutrition Investigations.

Soil studies.—Soil maps showing districtwise distribution of nitrogen, phosphoric acid and potash were prepared from the available data. Data for available phosphorus and potash were also collected.

Study of the absorption and retention of ammonia by various soils was undertaken and a method for this purpose was standardized. The bulk of the work on comparative studies of Indian soils carried out in previous years was written up for publication.

The distribution and factors affecting the availability of trace elements were studied. The percentage ratio of trace elements in the soil and in its clay was taken as a measure of their availability. This indicated the possibility of deficiency of trace elements in different soils. The study of good and bad patches of growth on the farm revealed the possibility of the deficiency in trace elements. The intake of trace elements was adversely affected by the intake of excess of potash. The effect of trace elements in increasing the yields of tobacco was studied in Delhi Guntur soils. This indicated that when the soil deficiency of its major elements, N, P and K was fully satisfied without undue excess of any one nutrient the application of trace elements increased the yields; otherwise it had no appreciable effect. While studying the deficiency diseases it was brought out that the deficiency of trace elements was associated with an excess intake of some other elements. Deficiency in zinc was associated with excess of manganese, deficiency of manganese with excess of iron and deficiency of boron with excess of potassium.

Alkaline formation was studied in Pusa soil and found to be of three types—one with excess of soluble sodium and calcium salts, the second with the excess of soluble sodium salts with absence of calcium salts, and the third with a small amount of soluble sodium salts but with the soil complex highly sodiumized. The patches were fugitive in nature. They disappeared in the monsoon and reappeared in winter. In Karnal soil the effect of an artificial mulch on the movement of salt in the top layer was studied. The mulch was beneficial in winter and summer but harmful in rains as it hindered the salts from being washed down.

Agrochemical studies.—Field experiments were conducted and the availability of manures was studied in the laboratory by measuring their nitrification at different levels of moisture in the soil. The descending order of availability in Delhi soil was ammonium sulphate, castor cake, mustard cake, green manures of cowpea and sunnhemp, activated sludge, compost and F.Y.M. There was heavy lodging of crops in plots in which the growth was heavy specially in plots receiving ammon. Sulp. treatment. The yields of crop followed the same trend as shown by laboratory studies. Agronomic observations of growth, etc. were also corroborative.

Preliminary experiments were conducted to find out if the yields of indigenous legumes could be increased by inoculation in the soil of appropriate active cultures of nodule bacteria with the seed. The results indicated that there was a possibility of increasing the yield by five to eight per cent by the treatment. The appearance of bacteriophage of the root nodule organism in the soils in which the same legume was grown continuously was under study. Three years' successive cultivation of the same legume in the plots favoured the incidence of bacteriophage. Therefore it was inadvisable to grow the same legume continuously in the same field year after year.

As mentioned earlier in this report, manuring of berseem with a heavy dose of superphosphate resulted in the increased yields of subsequent wheat crops without application of manures for a number of years. It was found that the manurial needs of Delhi soil were of available nitrogen and phosphates. In the light of this the development of soil fertility by means of berseem indi-

cated that phosphate additions stimulated the natural nitrogen-fixing power of the legume crop with the result that soil was left heavily rich in nitrogen as well as phosphorus. As the plots remained fallow in kharif the nitrogen in the crop residues nitrified and both nitrogen and phosphates were made readily available to the wheat crop. Thus a reserve in nitrogen and phosphorus was built up in the soil. Phosphate manuring of berseem and the microbiological status greatly improved the mineralization of plant residues by favourable conditions of the available mineral nutrient.

Microbiological studies.—Attempts were made to correlate the ratio between total organic carbon and the rate of decomposition to the crop yields. By the use of this ratio the quantity and quality of the soil humus was indicated and the status of inorganic nutrients in the soil was brought into prominence. This way of interpretation was found to be very promising.

In Delhi soil the decomposition of organic manures, rich in nitrogen, such as oilcakes, was found to be quite rapid and the rate of decomposition was greatly enhanced when phosphate was also added to the soil. The decomposition of green manures took more time than that taken for oilcakes and the farmyard manure and composts took still greater time for decomposition than the green manures. Wherever organic manures were associated with artificials the time taken for decomposition was greatly reduced. The yield of crops was closely correlated with the time taken for mineralization of various manures.

The recoveries of nitrogen and other nutrients by the crops also showed a close relationship with the rate of mineralization of organic manures, which determined the supply of nutrients to the crop.

Biochemical studies.—The study of milk and feeds of large number of sahiwal cows showed that calcium and phosphorus of the feeds was not sufficient to keep the balance of calcium and phosphorus positive in cows giving more than 30 lb. of milk per day. The ratio of Ca: P_2O_5 in milk varied in different cows.

The effect of phosphate manuring of berseem on its feeding quality was studied for comparison. Berseem manured with complete artificials was also included in the study. The uptake of calcium and phosphoric acid by the crop was estimated. Calcium uptake of berseem, manured with phosphate and with complete artificials was almost the same but it was much more than in the crop of unmanured plots. The phosphorus uptake of berseem, manured with phosphate only, was higher than that of berseem manured with complete artificials. The phosphate uptake of manured berseem was much higher than that of unmanured berseem. The growth of rabbits fed only with the crops of berseem under these treatments showed that berseem manured with phosphate was decidedly superior to berseem manured with complete artificials. Both the manured crops were far superior to the unmanured crop. The nutritive values of the crop seemed to depend upon the phosphate uptake by the crop. The less uptake of phosphate by the crop manured with complete minerals than that by the crop manured with phosphate alone may be attributed to the effect of potash included in complete mineral treatment. It was observed in Delhi soils that increase in potash decreases the uptake of minor elements as well. The depressing effect of potash on yields and quality in Delhi soil was indicated by these and other experiments.

The changes taking place in tobacco leaves during curing were studied. The dry matter decreased by 15% during curing. Ammonial and amide nitrogen

progressively increased the degradation of proteins into soluble form was marked towards the end. There was remarkable increase in sucrose content with decrease of reducing sugar.

4. Investigations on Pests of Plants

Insect vectors of virus diseases.—The leaf-curl virus disease and its vector, the white-fly, were commonly observed on a number of plants at Delhi. Some plants of a weed, *Sida rhon bifolia*, of chillies, and *papaya* artificially infected with A-type of tobacco virus showed symptoms of attack, the first two showed symptoms after 2-5 weeks and third one after 9-10 months.

Spraying experiments were conducted near Jhansi for controlling white-fly on tobacco crop, the insecticide used was fish oil rosin soap in the proportion of 1 oz., in 1 gallon of water. The incidence of the pest was 5.4% as against 6.9% of the control plot when spraying started, but after 6 syrayings the incidence was 33.3% and 78.8% respectively.

Insect population studies.—The contention that percentage incidence is often misleading was again confirmed. Besides, it was shown that method of recording incidence of some pests in terms of 'number per unit area of leaf surface' is not at all correct. The idea of the Biograph and Biometer has been perfected to a great extent. A biometer has been constructed and attempts made to estimate by biometric method the pupal periods of *Earias fabia* under field condition have given encouraging results.

The collection of basic and climatic data for the long range experiments on population fluctuation has been continued, and the data collected under three heads: (a) field census, (b) field rearing and (c) meteorological observations.

Pests of stored food-stuffs.—Disinfection of pests of *Jowar* by sun-heat treatment during the dry summer months showed that the treatment was effective in heaps up to 1 inch thick on 'pucca' floor and ½ inch thick on 'kutcha' floor when exposed for 15 minutes and the temperature of the heap was 131°F. or above. A number of non-poisonous chemicals were tried as preservatives. D.D.T. and 666 were tried as dusts at the rate of 1|5,000 and 1|10,000 after diluting with chalk and mixed with grain against 5 stored grain pests. Complete mortality was obtained in 3 days time in all cases except with grubs of 'khapra' which did not die even after 17 days exposure. This method looks very promising particularly for use in seed store.

Carbon bisulphide was tried as a fumigant in different dozes and its effectiveness was found to vary with the temperature and humidity prevailing as also the duration of exposure. At higher temperature stored product pests were killed in shorter time than at lower temperatures.

Survey of Icerya purchasi.—This pest was observed for the first time in Chingleput, Chittoor and Anantapur districts of Madras Presidency. It was also recorded for the first time from some localities of Madura and Salem districts. The pest invaded all these places through the agency of seedlings of *Casuarina equisetifolia* imported from infested areas. The pest has restricted distribution on citrus plants; it has been found doing serious damage only at Kodaikanal in Madura district and on an estate in the orange valley of Nilgiri district, but is found in small numbers at other localities in Madura district and at Bangalore.

Seven new host plants of the pest were found during the year. Three predators of the pest found, have been identified. Five other species of *Icerya* were collected and their distribution and host plants recorded.

The survey of San Jose Scale, *Quadraspidiotus perniciosus* was continued along with *Icerya purchasi*. In all the localities examined for the latter pest. San Jose Scale was found only in the Nilgiri and Shevaroy hills.

Biological control of sugarcane pests.—Liberations of *Trichogramma* parasite against sugarcane borders were continued at three sub-stations. At Setabganj (Bengal) there was no initial parasitization of root borer, but in August the parasitization in the colonised block was 21.85% as against 5.5% in the control blocks and in October the respective figures were 28.68% and nil. There was no initial parasitization of stem borer, but in August the parasitization was 21.63% in the colonised blocks against 1.5% in control blocks, and in October the respective figures were 36.58% and 27.7%. The average yield from the colonised blocks was 206.2 maunds against 635.2 maunds from the control blocks. At Cuttack the parasitization of stem borer during August was 57.3% in colonised plots as against 16.5% in control plots. The average yield was 320.5 maunds in the control plots, 249.7 maunds in six liberation plots (plots affected by floods and hence low yield) and 412.35 maunds in 12 liberation plots. In Sehore (Bhopal) in the 1944-45 experiments in July, the average egg parasitization of *A. sticticraspis* in the colonised plots was 9.68% against 19.76% in the control plots but in September the respective figures were 10.75% and 3.87%. In December, the parasitization came down to 5.0% and nil respectively. Before harvest, the egg parasitization was nil in all the plots.

The biology of *Stenobracon deesae*, braconid ecto-parasite of top, stem and root borers of sugarcane was studied. Similar studies were made of an endo-parasite, *Apanteles flavipes*, of stem borers of sugarcane. Observations on the life-histories of *Nimboa basipunctata* and *Brumus suturalis* predators of Pyrilla were also made. Observations made on *Trichogramma minutum* show that a maximum of 30 eggs were parasitized at 25°C. and 90% relative humidity and that the adults lived for a maximum period of 7 days when fed on 10% sucrose solution, while unfed adults lived for 2.5 days.

Experiments carried out at Karnal to conserve *Pyrilla* egg parasite showed that such plots gave an increased yield. Observations made on the occurrence of these parasites showed that the degree of parasitization varied from 7.4% in November to 23.42% in February. Mass rearing of *Trichogramma* continued throughout the year and 30.5 million parasites were bred.

Mass rearing of *Microbracon gelechiae*, a parasite of potato tuber moth got from Canada, was under progress; 300-400 parasites are now being bred daily.

Studies of termites.—A thorough survey was made of the Institute area in New Delhi for termite species. 121 collections were made and it was observed that *Cyclotermes obesus*, with its three closely allied varieties, was the commonest species here.

Insecticides and fumigants.—The insecticidal properties of opium and its various extracts and tobacco were studied in the laboratory. Opium and opium marc (a waste product left after the extraction of pure opium) were tried as stomach poisons against larvae of *Euproctis lunata* and *Bombyx mori*,

but gave negative results. As contact insecticide, a 2% solution of opium marc had no injurious effect on larvae of B. mori and 20% solution caused 64.5% mortality. Dilute acetic acid extract of opium marc showed marked insecticidal value, a 5% solution yielding 85% mortality. Suspension of crude opium in water proved strongly toxic giving 92% kill at a strength of 0.2%. Almost similar results were obtained from experiments on *Bagrada picta* adults. A 5% solution of acetic acid extract of opium marc and 0.2% suspension of crude opium brought about 91.9% and 83.5% mortality respectively.

Samples of 42 varieties of tobacco were studied for their nicotine contents and insecticidal properties. Preliminary results of chemical and biological tests carried out so far on *Bombyx mori* larvae indicate that a sample containing highest nicotine content (1.99%) produced the highest mortality (80%) and a sample having lowest nicotine content (0.59%) gave the lowest mortality (13.3%).

5. Locust Control

Baluchistan was again free of swarms in spring when usually breeding takes place in that area. Regular swarms reached India in the last week of March. They invaded various parts of Baluchistan which had received good rainfall leading to extensive breeding in Mekran, Kharan and parts of Jhalawan. Invasion by swarms continued throughout April towards the end of which month Mastung and some other areas in Sarawan were also invaded followed by oviposition and hopper emergence. Control work in Baluchistan continued up to first week of June. About 150 troops belonging to Bikaner Ganga Risala helped in control operations. The pest was successfully controlled leaving very few escapes. However, invasion by swarms from Arabian and Persian side continued during June and July, by which time conditions in Baluchistan were dry. Therefore swarms reached Sind and Punjab direct and breeding started in Punjab in several districts. Fairly successful control operations were carried out but apparently several hopper bands escaped destruction particularly in forest areas and some swarms developed. These and the exotic swarms referred to above entered Rajputana in June-July where with the break of monsoons breeding started over extensive tracts, the eastern Rajputana being most highly infested.

6. Plant Diseases

The testing of resistance of different varieties of wheat to loose smut was continued. Of the 74 varieties tested against the Pusa collection of the smut, 35 did not take infection and nine were only slightly attacked. Of the eighty four varieties including the 74 mentioned above were tested against the Punjab collection of the smut, 39 did not take infection and 26 were only slightly attacked. Some wheat varieties obtained from Central Provinces, Sind and the Punjab have also been tested to find out their resistance to loose smut.

Work on physiologic races of loose smut. in progress since 1941, has not given consistent results. A set of Indian wheats has been selected as differentials. There is a suspicion that there may be two races of this smut in India.

Additional experimental evidence to prove that the Karnal Bunt is airborne has been obtained.

Results obtained from seed treatment trials against barley "covered smut" have been unsatisfactory as the trials had to be done with naturally infected seed and it has not been possible to get such seed having the same spore load of infection.

The fungus responsible for the long smut of jowar has been brought into culture and the mode of transmission of this disease will be studied.

The testing of resistance of pigeon pea varieties to *Fusarium* wilt was continued. IP 80 proved to be immune while IP 41 and hybrid 5(D41-2-4) were highly resistant. Canker of pigeon peas was found to be particularly severe on varieties from Jamaica.

Tubers of 40 varieties of potatoes were tested to see their reaction to attack by potato-rot organism. Tubers of cult. 296, 394, Aya Papa and M 09 were found to be wholly resistant to infection by that fungus while cult. 230, Hyb. 2, 9, 11 and J 07 were highly resistant. The remaining varieties were highly susceptible. No definite conclusions could be drawn from the experiments connected with the enzymes obtained from the cultures of the same fungus.

Virus diseases of Potato.—Solanum virus 3 was recovered from some potato varieties and its properties were noted. Mixtures of Solanum Virus 1 and 2 were found to be present in some of the varieties. The potato crop in the Punjab and United Provinces hills was inspected for disease incidence. Tubers from apparently healthy plants were under test to see their freedom from diseases. The Central Farm for seed certification was established at Kufri in Simla Hills.

Work on production of seed potato tubers relatively free from virus diseases was started at Karnal during the year. About 40 acres were under this crop. Roguing operations were carried out and harvested seed was stored at Meerut in a cold storage.

Studies on virus diseases of tomatoes were continued.

Transmission of red-rot fungus of sugarcane has once again been shown to be through infected soil, irrigation water and the nodal regions of the cane. Under Karnal conditions the fungus remained viable in the soil for not more than six months. Of the 120 varieties tested Co. 205 was found to be fairly resistant to the red-rot fungus while the rest were susceptible. There does not seem to be parasitic specificity in the 48 isolates of the fungus though they appear to differ in their virulence.

One hundred and twenty varieties of canes were tested for resistance to smut. Fifty eight were found to be fairly resistant, 33 moderately susceptible and 29 highly susceptible.

Examination of different samples of paddy leaves showed that 79 were attacked by Helminthosporium, and 118 by Curvularia. Measurements of spores indicated that a majority of the Helminthosporium isolations were of *H. oryzae* while two isolations of Helminthosporium from Orissa and one from Sind had consistently smaller spores.

Two new genera of rusts were discovered and described while the species of *Ravenelia* were reinvestigated. Several new species of smuts were found while *Ustilago burkillii* and *Entyloma eugeniarum* were excluded from the smuts, as the former proved to be an Ustilaginoidea while the latter proved to be the immature stroma of a phyllachoroid fungus. India collections of *Uromyces, Leptosphaeria* and *Phyllosticta* were under study.

The Indian Type Culture Collection of Fungi was taken over from the Imperial Council of Agricultural Research as a part of the Mycological Section's activity from April 1945. About 200 cultures were supplied on request to various people in India and to a scientist in China. Forty nine cultures were obtained from abroad and added to the collection. Three hundred and forty two specimens were added to the Herbarium and specimens were sent to 17 persons in India and abroad for comparative study. Exsiccatae sets were under preparation for exchange with European and American Herbaria.

7. Special investigation in furtherance of the war effort

Besides the work already mentioned under the sub-head, Agronomy and on Locust Control the following investigations are undertaken.

Rubber investigations.—The rate of formation of rubber in *Cryptostegia grandiflora* was studied. Tapping of plants on the alternate days for rubber gave maximum yields of rubber. The latex and yield of rubber were affected by seasons. The best season for tapping was the period from December to March when latex was copious and rich in rubber contents. Experiments to obtain rubber by fermentation of the plant material were not encouraging. The retting of tissues was quite good but the amount of rubber contents in the tissues was very low.

Experiments were also undertaken to determine the best method, the best age of plant and the best time of the year for pruning plants to promote the maximum growth possible were in progress. This method of obtaining rubber was less laborious and more economical than tapping of latex and could give a yield of about 90-110 lbs. rubber per acre per year at a comparatively lower cost.

The production of butul alcohol and acetone by microbiological fermentation.—The various aspects of industrial utilization of the cultures were studied. A factory was erected by a private company under the aegis of the Supply Department to exploit the process for which a patent was obtained.

Utilization of ammonium nitrate and its mixtures with T. N. T. from surplus ammunition stores as a fertilizer.—A number of experiments were conducted to obtain information about the manurial value of ammonium nitrate and to find out if a small amount of T. N. T. which was likely to be associated with the ammonium nitrate recovered from the surplus ammunition stores was in any way harmful to variety of crops. It was found that in Delhi soil ammonium nitrate when associated with phosphates increased the yield considerably. The presence of T.N.T. to an extent of 3% did not affect the crops adversely and the manure could be used with equal advantages both for kharif maize or rabi wheat. The best form of phosphates was superphosphate. Bonemeal as well as rock phosphate could be used as phosphatic manures in association with ammonium nitrate but the beneficial effects were not so high as with superphosphate.

Air foam compound as fire extinguisher.—A compound prepared from *Solanum xanthocarpum* was tried for extinguishing petrol fire on a field scale. The compound produced foam which was equal to soap from compounds but was not so good as compounds of animal proteins.

III. GENERAL ADMINISTRATION

Charge.—I continued to work as Director of the Institute throughout the year and Dr. B. P. Pal, Imperial Economic Botanist was appointed as Joint Director in the vacant post from 7th November, 1944.

To afford further relief to Dr. H. S. Pruthi, Mr. P. V. Isaac, Second Entomologist was appointed to officiate as Imperial Entomologist from 1st February, 1945, Dr. Pruthi continued to direct Locust Campaign and co-ordinate Entomological Research in India in addition to his duties as whole-time Director of the Institute. He was allowed by the Government of India to use the designation of Director of Locust Control from the middle of March 1945 for the purpose of directing the locust campaign and co-ordinating Entomological Research in India.

Staff.—The Botanical, the Agricultural and the Chemical Sections remained throughout the year in charge of Dr. B. P. Pal, Mr. C. H. Parr and Dr. S. V. Desai, the last named holding charge of the Chemical Section in addition to his duties as II Agricultural Chemist. The Sugarcane Station, Coimbatore, remained throughout the year in charge of Mr. N. L. Dutt. A list of the gazetted staff together with such changes as took place in the various Sections is given in Appendix I.

Schemes of research financed by the Imperial Council of Agricultural Research.

The following Research Schemes financed by the Imperial Council of Agricultural Research continued functioning at the Institute (i) Development Scheme (ii) Sugarcane Sub-station Karnal, (iii) Research on Diseases of Sugarcane, (iv) Research on Genetics of Sugarcane, (v) Potato and Wheat Breeding Sub-station, Simla, (vi) Tobacco Breeding Sub-station, Guntur, (vii) Biological Control of Sugarcane Pests (viii) Storage of Jowar (ix) Physiology of Sugarcane, (x) Soil Survey, (xi) Type culture Fungi, (xii) Survey of Icerya purchasi, (xiii) Potato Certification, (xiv) Intermediate Hill Station, Bhowali.

From 1st April, 1945, the Sugarcane Research Schemes are being financed by the newly constituted Indian Central Sugarcane Committee who have sanctioned extention of the schemes for one year only pending consideration of and decision on the Report of the Sugarcane Research Survey.

A new scheme for multiplication of comparatively disease-free seed potatoes at Karnal for immediate distribution to growers in connection with the grow more food campaign at a gross cost not exceeding Rs. 2,14,000 (round) for three years in the first instance has been sanctioned from 1st May, 1944.

Training.—Sixty nine candidates applied for admission to the post-graduate courses beginning in October, 1944 of whom 47 were recommended by the Provincial authorities. Twenty nine applicants were selected for admission, five in Entomology, seven in Botany, four in Mycology, nine in General Agriculture, one in Agricultural Chemistry and three in Sugarcane Breeding. Of these one in Sugarcane Breeding left the course as the climate of Coimbatore did not suit him. Thirteen students completed the course during the year and were awarded the Institute Diploma, six in Botany, one in Agricultural Chemistry, two in Entomology, two in Mycology and two in Sugarcane Breeding. The one-year course in Farm Organisation and General Farm Engineering was completed by one student. Six Inspectors, viz., two

from Bihar, one from Assam, two from United Provinces and one from Bengal were given training in virus work in connection with the scheme for multiplication of comparatively disease-free seed potatoes. Besides the above, facilities were afforded to a number of short course students and honorary research workers as per details given in Appendix II.

Library.—The total number of publications received in the Library both in exchange and by purchase was 1413. Over 3722 books were issued out on loan.

IV. ACCOUNTS

The total expenditure of the Institute and its Sub-stations at Karnal and Coimbatore during the financial year ended March, 1945 amounted to Rs. 11,70,155.

	Rs.
General expenditure of the Institute including the office of the Director, Irrigation, Power Supply, Gas Plant and the Estate Establishment	2,46,128
Agriculture Section	1,76,413
Mycology Section	45,743
Entomology Section	55,725
Chemistry Section	74,014
Botany Section	59,971
Statistician	10,340
Headquarters Total	4,22,706
Sugarcane Station Coimbatore	98,109
Locust Warning Organisation	2,51,325
Total Expert Staff	7,72,140
Agricultural Sub-station, Karnal	1,20,742
Botanical Sub-station, Pusa	31,145
Total Experimental Farms	1,51,887
Total Expenditure	11,70,155

The expenditure of the various research schemes financed by the Imperial Council of Agricultural Research amounts to Rs. 2,63,043 as shown below which was met from the funds provided by the Imperail Council of Agricultural Research.

		Rs.
(a)	Development Scheme	55,871
(b)	Sugarcane Sub-station, Karnal	8,743
(c)	Research on Diseases of Sugarcane	11,310
(d)	Research on Genetics of Sugarcane	582
(e)	Potato & Wheat Breeding Station, Simla	33,155
(f)	Tobacco Breeding Sub-station, Guntur	22,165
(g)	Biological Control of Sugarcane, Borers	21,549
(h)	Storage of jowar	4,159
(i)	Physiology of Sugarcane	5,831
(j)	Type Culture Fungi	1,538
(k)	Icerya purchasi	18,736
(l)	Potato Certification	8,857
(m)	Multiplication of Seed Potato at Karnal	44,005
	Total ..	2,63,043

The receipts of the Institute and its Sub-Stations amounted to—

	Rs.
Main Institute	74,750
Agricultural Sub-station, Karnal	84,386*
Sugarcane Sub-Station, Coimbatore	9,446
Botanical Sub-station, Pusa	701
Locust Warning Organisation	4,371
Total ..	1,73,654

*Vide Income and Expenditure Account reproduced below.

Income and Expenditure Account for the year ended March, 1945—Agricultural Sub-station, Karnal.

Income

		Rs.
1.	By sale of Dairy produce	42,779
2.	By sale of Farm Produce	19,504
3.	Miscellaneous receipts	11,426
4.	Live-stock	20,677
	Total ..	84,386

Expenditure

		Rs.
1.	Pay of officers and establishment	34,256
2.	T. A.	222
3.	Dearness allowance	13,737
4.	Feed of Dairy cattle etc., ...	12,088
5.	Production of grain and fodder	41,360
6.	Workshop	1,974
7.	Fuel, light, water, etc.	3,401
8.	Miscellaneous Contingencies	4,019
9.	Repairs to plant and machinery	9,355
10.	Petty construction and repairs	1,898
	Total ..	1,22,310

REPORT OF THE IMPERIAL AGRICULTURIST

(C. H. Parr, I.A.S.)

I. AGRONOMY, AGRICULTURAL SECTION, NEW DELHI

1. *Season and Crops.*—The total rainfall from June, 1944 to May, 1945 amounted to 28.68 inches against 22.08 and 28.86 inches during 1943-44 and 1942-43 respectively.

About half the annual rainfall was received in well distributed showers during the month of July. In August only 1.14 inches was received in 11 showers and irrigation was necessary to save the *kharif* crops from drought. A heavy downpour of 5.59 inches was registered on September 1, which though welcome after the dry August, flooded the *kharif* crops at low lying places. There were falls amounting to 2.61 inches of rain during the first week of October 1944, which enabled the *rabi* crops to be sown without irrigation. The shower proved beneficial to the standing *kharif* crops but caused lodging in the sugarcane.

Frosts occurred during December and January. This coupled with deficient winter rains delayed growth particularly in berseem and other fodders. Growth of all crops became vigorous during February when the season warmed up. Despite these adverse conditions very good yields were obtained from *rabi* crops which may be partly attributed to the clear weather and comparatively low temperatures of March and April.

Sterility appeared in early pigeon-pea as a result of which about 15% of the branches did not come to bearing. In the remaining branches, the pods were badly attacked by *Adhisura Atkinsoni* and *Agronyza obtusa*. The yields obtained therefore were far below expectation.

The oil seed crops were badly infested with *Bragrada picta* and in consequence suffered considerably in yield. The yields of some of the crops grown on large scale were as follows:—

Cotton L.S.S.—12.54 mds. (*Kapas*),

Maize No. 2—18.80 mds.,

Barley I.P. 13—43.95 mds.,

Wheat Punj. C. 518—38.95 mds.,

Oats I.P. 2—30.29 mds. &

Peas I.P. 29—23.30 mds. *PER ACRE.*

During the year under report farm implements and equipment, bullock strength and labour were at a very low ebb. No tractor was in working order and most of the work cattle old and their number inadequate. Threshers and other machines are worn out and spare parts unprocurable. At the busiest season labour was practically unobtainable. It is therefore, gratifying to note, that in spite of all these handicaps, the work was somehow managed and good yields of crops were obtained. Some improvement in these conditions has since been effected by the provision of a tractor and a harvester-thresher. A complete overall of all equipment, however is urgently required.

Since efficient and reliable labour is difficult to obtain even at the comparatively high rates now paid, the fullest mechanisation of the farm possible is necessary to enable the large experimental programme to be carried out

effectively. A very large experimental area has to be sown and harvested all at about the same time. This cannot be done by bullocks. Every modern piece of equipment which will provide for optimum sowings and accurate harvesting of field experiments is necessary if results of value are to be obtained. Much inaccuracy in field experimentation in the past has undoubtedly been caused by unreliable labour. The days when hundreds of plots have to be threshed by hand should be relegated to the past. The opportunity should now be taken to equip this experimental station with equipment which will ensure reliable work and reliable results.

The phosphate manuring of berseem has been found not only to increase the yield of berseem but also to leave behind a big reserve of fertility for the succeeding crops, the area under berseem has been increased to provide for the manuring of every field through berseem once in five years. Similarly an area of 27.75 acres has been put under perennial irrigated grasses for 2 or 3 years with a view to seeing the part such alternate husbandry practices can play in increasing the fertility of Indian soils.

2. *Seed Supply.*—As usual there was a big demand for improved seeds from various provinces and States which was met, as far as possible from the Delhi and Karnal Farms. The total quantity of seeds supplied during the year was 2674.8 lb.

3. *Fodder Supply.*—Sufficient fodder was raised and preserved as silage and hay for cattle. On account of shortage of labour and bullocks all the *Jowar* intended for silage could not be used for that purpose. Consequently it was cut and dried into hay.

4. *Farm Yard Manure.*—The practice of carting dung and litter straight from the byres to the fields was continued. Only that amount of dung and litter was stored in the pits as was required for experimental purposes.

5. *Work on Sugarcane.*—Eleven new varieties of sugarcane were received from Coimbatore and grown in observation plots. Out of these, the following which are given in order of merit appear promising:—Co. 611, Co. 613, Co. 620, Co. 621 and Co. 622.

6. *Advisory.*—Detachments of the Rajputana Rifles were given instruction twice a month in modern farming methods and live stock management. In addition a batch of twenty soldiers and an Indian Officer of the 10th Bat. 6th Rajputana Rifles, received practical training in Agriculture for a period of 6 weeks. Enquiries received from all parts of India regarding problems concerning general agriculture and live stock managements were dealt with.

7. *Field Experiments (Delhi and Karnal).*—The programme of field experiments has been considerably expanded to develop further some important results arising from certain lines of investigation, such as the phosphatic manuring of legumes to build up soil fertility etc., which have been initiated by the Agricultural Section over the past five years. Considerable expansion of the supervising staff is now required to cope with the increased work efficiently.

(a) *Manurial experiments in the Scheme for the Development of Research.*—The undermentioned experiment suggested by Sir John Russell was continued.

Comparison in field experiments of the relative values of nitrogen in green manures, farm yard manure, compost, oil cakes and sulphate of ammonia.

estimating the recovery of nitrogen by the crop and of the changes brought about in the soil.

The old series of this experiment was repeated in Middle Block A-2, but owing to low yields in previous crops, the doses of manures were doubled in all treatments, excepting in treatment K, where the dose of farm yard manure was increased from 60 to 80 lb., nitrogen per acre. As some plots had in previous yields shown evidence of inherent infertility, alternate blocks in this series were further treated with the minor elements, boron and manganese in addition to the other manures. The stand as well as the final yields of wheat, I.P. 165 were very satisfactory and there was very little lodging in this field. Although the differential response to the manures was not statistically significant, due to the high value of the experimental error, increases in the yield of grain ranging from 188.5 to 421.0 lb. per acre were obtained from the manurial treatments over the 'no manure' yield of 1932.4 lb. per acre. At a dose of 40 lb. nitrogen per acre, rape cake and activated sludge have proved more efficient in this series than leaf compost and farm yard manure. Almost the same position is retained by these four organic manures when they are supplemented with superphosphate at 40 lb. P_2O_5 and sulphate of potash at 40 lb. K_2O per acre, although the yields of grain are somewhat lower than those obtained when the organic manures were applied alone, except in the case of leaf compost. With sulphate of ammonia at 20 lb. nitrogen and superphosphate to make up 40 lb. P_2O_5 per acre in the mixture, leaf compost at 20 lb. N has shown an increase of 20.70 and 14.25 per cent in grain and straw, whereas farm yard manure with these fertilisers at the same dose, as in the above mentioned treatment, has produced an increase of 18.78 and 16.73 per cent in grain and straw. The effect of the minor elements, boron and manganese has been to decrease the yields of grain and the Agricultural Chemist proposes to study the cause of this in greater detail next year.

Owing to the high values of the experimental error which have ruled in this experiment since it was started in 1941-42, due to high soil variation, it was decided to start a new series in another field in Main Block 9-B and 9-C and the manurial treatments included green manuring with sunn-hemp and cowpeas and manuring with rape cake, castor cake, farm yard manure, leaf compost and sulphate of ammonia on the basis of 40 lb. nitrogen per acre. In the manured plots wheat I.P. 165 showed excellent growth but the heavy crops in these plots and especially that in the sulphate of ammonia treatment lodged badly. High yields of grain and straw were obtained, but the results were masked by the effects of lodging and by the incidence of rust in the lodged plots.

Details regarding the chemical aspects of this problem will be furnished in the report of the II Agricultural Chemist.

(b) Phosphate manuring of legumes

The work initiated by this Section on the relationship of phosphates to legumes in regard to (1) increase in the yield of the legume, (2) increase in the phosphate and calcium contents of these crops, (3) increase in the yields of cereals following the manured legumes, (4) increase in nitrogen and phosphate content of the cereals and (5) the role of phosphate manuring of legumes in developing soil fertility, constitutes one of the major lines of investigations, the results of which call for further detailed research.

(i) *Manurial experiment No.* 1.—Wheat C. 518 was sown for the second year in Top block 1-D to 1-F in which phosphate manured berseem followed by unmanured cowpeas had been grown continuously for the 3 years, 1940, 1941, 1942. Without any further manuring of any kind higher yields of wheat were obtained in 1944-45 than in the year 1943-44 especially in the treatments with high doses of phosphate. Evidence has been obtained from this experiment that phosphatic manuring of berseem not only provides higher yields of very nutritive fodder, but that it also builds up soil fertility of a stable character, for the benefit of cereal crops which may follow the phosphate manured berseem. The yields of wheat are given below:—

Yield of grain in Maunds (= 82.3 lb.) per acre

	Cowpea-wheat Rotation		*Fallow-wheat Rotation*	
Treatment per acre	1943-44	1944-45	1943-44	1944-45
A. F.Y.M. at 40 lb. N ..	16.72	15.78	20.23	21.16
B. F.Y.M. at 80 lb. N ..	20.91	18.05	27.02	32.56
C. F.Y.M. at 120 lb. N ..	22.27	23.82	27.49	31.04
D. Activated Sludge at 80 lb. N	23.10	20.13	26.57	29.90
E. Rape cake at 80 lb. N ..	16.12	15.03	28.59	28.02
F. Am. Sulph. at 80 lb. N ..	15.23	16.73	20.95	25.64
G. Superphosphate at 132 lb. P_2O_5	24.18	27.31	30.80	35.13
H. Superphosphate at 198 lb. P_2O_5	26.16	32.61	29.85	35.21
I. Superphosphate at 264 lb. P_2O_5	25.53	36.10	25.68	37.85
J. F.Y.M. at 80 lb. N plus Super at 132 lb. P_2O_5 ..	26.35	32.89	25.54	38.49
K. Complete artificials on the basis of treatment 'B' ..	23.91	27.13	31.33	33.71
L. No manure	14.94	14.65	23.99	25.45

The increased yields of wheat obtained in the two years 1943-44 and 1944-45 from the plots in which Superphosphate was applied to berseem at 4, and 6 maunds per acre in each of the three years 1940, 1941 and 1942 have met the cost of manures and left a good margin of profit. Taking the cost of superphosphate at Rs. 5|8|- per maund and the price of wheat at Rs. 3 per md. (pre-war prices) and reckoning wheat straw as worth annas eight per maund these treatments have given profits of Rs. 20.5 and Rs. 16.2 so far and the full possibilities of the high phosphate manured plots have not yet been exhausted. Over and above this 526 maunds of extra berseem fodder in three years and 81 maunds of extra cowpeas in four years have been obtained

free of any cost. At the present levels of prices the profits would be much greater. It is proposed to grow wheat in these plots for a number of years without any further manuring in order to see how long the fertility effects last in the high phosphate treated plots.

(ii) *Manurial experiment No.* 2.—Wheat (C.518) was sown for the first time in Top Block 3-B in a field, in which berseem had been grown for three years with much lower doses of phosphates in the form of superphosphate and farm yard manure, individually and in combination with each other. The results follow the same trend as those obtained in experiment No. 1 and show that increasing doses of phosphates particularly superphosphate not only produce increased yields of berseem, but also of unmanured wheat following berseem as given below:—

Yield of wheat grain in Maunds (=82.3 *lb.*) *per acre*

Treatment per acre.	*Cowpea-wheat Rotation.*
A. F.Y.M. 16 lb. P_2O_5	25.88
B. F.Y.M. 32 lb. P_2O_5	31.78
C. F.Y.M. 64 lb. P_2O_5	31.16
D. Superphosphate 16 lb. P_2O_5	27.87
E. Superphosphate 32 lb. P_2O_5	31.94
F. Superphosphate 64 lb. P_2O_5	41.15
G. Super. 8 lb. P_2O_5 plus F.Y.M. 8 lb. P_2O_5	26.90
H. Super. 8 lb. P_2O_5 plus F.Y.M. 24 lb. P_2O_5	30.81
I. Super. 8 lb. P_2O_5 plus F.Y.M. 56 lb. P_2O_5	38.24
J. F.Y.M. 8 lb. P_2O_5 plus Super. 24 lb. P_2O_5	29.95
K. F.Y.M. 8 lb. P_2O_5 plus Super. 56 lb. P_2O_5	38.29
L. No manure	25.29

An initial dose of 2 maunds of concentrated Superphosphate or 64 lb. P_2O_5 therefore appears to be the minimum for berseem to show effective results under Delhi conditions.

(iii) *Availability of* P_2O_5 *in composted and non-composted bonemeal.*—Previous experience at Delhi has shown that berseem does not respond to manuring with bonemeal as readily as with other phosphatic manures. A new experiment was started in 1944-45 to examine the effects of bonemeal applied alone or after composting it with Sunn-hemp or crude Sulphur ore. The manures were applied at 120 lb. P_2O_5 per acre. The yields per acre of green berseem obtained were nearly 344 mds. from the 'No manure' treatment 349 mds. from bonemeal alone, 364 maunds with bonemeal composted with 200 maunds of Sunn-hemp and 379 mds. from Sunn-hemp buried as green manure. Bonemeal composted with half its own bulk of crude Baluchistan Sulphur ore

produced an yield of 485 maunds of green berseem per acre. This compost with sulphur ore, therefore, deserves further trials.

(iv) *Efficiency of different forms of phosphates applied to berseem alone and in combination with other manures.*—Superphosphate, ammonium phosphate, bonemeal and basic slag were applied to berseem with and without green manure (sunn-hemp), farm yard manure, sulphate of potash and no basic manure. Significant increases were obtained from the ammonium phosphate treatment, especially in combination with farm yard manure and green manure. An extra early cutting of green berseem and higher yields were obtained from the ammonium phosphate plots, as will be seen from the following figures:—

Average yields of green berseem in mds. (= 82.3 lb.) per acre

Basic manurial treatments per acre	No fertiliser	Ammon phosphate	Superphos	Bone meal	Basic Slag
No manure	246	348	262	254	252
Farm Yard Manure at 120 lb. P_2O_5	309	443	242	358	317
Green manure	244	429	320	308	229
Sulphate of potash at 50 lb. K_{20}	265	377	317	304	283

N.B.—Phosphates applied at 120 lb. P_2O_5 per acre.

(v) *Direct and indirect manuring of wheat in a cowpea-wheat rotations.*—In previous experiments cowpeas grown after manured berseem showed no significant increases in yields of fodder, although the P_2O_5 and CaO contents were increased. A new experiment was started in 1944-45 to study the effect of the direct manuring of cowpeas and to see the residual effect on wheat. Although little differential effect to the manures was observed with cowpeas, significant differences in yields of wheat following the cowpea crop were observed in certain phosphate treatments given to the cowpea crop as will be seen from the following statement:—

Crop	Manures applied to	Average yields of green cowpeas and wheat grain in maunds per acre.							Critical
	Cowpeas	F. Y. M. 80 lb. P_2O_5	Superphos 132 lb. P_2O_5	F. Y. M. 40 lb. P_2O_5 + Superphos 61 lb. P_2O_5	F. Y. M. 80 lb. P_2O_5 + Superphos 132 lb. P_2O_5	Nil	Nil	Nil	Difference 5%
	Wheat	Nil	Nil	Nil	Nil	Superphos 132 lb. P_2O_5	Am. Sulph 80 lb. N	Nil	Level
	Treatment	A	B	C	D	E	F	G (Control)	—
Cowpeas K. 700	Yield of green fodder	156.01	152.36	169.86	160.63	136.20	147.50	153.82	27.16
Wheat C.518	Yield of grain	28.18	25.39	25.82	29.95	26.67	25.33	23.39	3.41

(vi) *Direct and indirect manuring of wheat, etc., with phosphate.*—Direct application of superphosphate alone and in combination with sulphate of ammonia and sulphate of potash, or with sulphate of potash alone has effected increases in yield of green berseem from about 52 to 82 per cent and of wheat from 24 to 35 per cent over the yields of the 'no manure' treatments. Similarly increases ranging from 50 to 131 per cent have been secured in the case of Peas, I.P. 29. The indirect effects of the fertilisers on these crops as they appear in the rotation will be seen in the following years.

Berseem from this experiment was analysed periodically by the Second Agricultural Chemist and was used by him in a feeding experiments with rabbits to test the effect on relative growth of berseem from three different treatments. The percentage of calcium from the unmanured treatment was 2.45% and Phosphorus 0.34% and the relative growth of the rabbits was the least in this group. Berseem from plots manured with Superphosphate at 66. lb. P_2O_5 per acre contained calcium—2.70% and Phosphorus—0.58% and the rabbits put in the best growth when fed with this fodder. Berseem from the complete artificial treatment with 40 lb. N plus 66 lb. P_2O_5 plus 40 lb. K_2O contained 2.80% calcium and 0.54% Phosphorus but the relative growth of rabbits was lower than those in the Superphosphate treatment. Further details of this work has been provided in the report of the II Agricultural Chemist.

(vii) *Direct and indirect manuring of paddy in rotation with (i) berseem, (ii) peas, (iii) gram, (iv) wheat and (v) fallow.*—In order to supplement the above mentioned phosphate manuring experiments at New Delhi, a series of new experiments with paddy followed by leguminous or cereal crops with direct and indirect phosphate and other manuring has been started at Karnal.

(viii) *Phosphate manuring of berseem with and without basic manuring with farm yard manure or green manuring with sunn-hemp.*—Ammonium phosphate, superphosphate and bonemeal at 120 lb. P_2O_5 per acre and combinations of bonemeal at 60 lb. and ammonium phosphate or superphosphate at 60 lb. P_2O_5 per acre were applied to berseem in three fields with (a) no basic manure, (b) green manuring with sunn-hemp and (c) manuring with farmyard manure (raw dung plus litter) applied at 10 tons per acre. The details of treatments and yields obtained are shown below:—

Average yields of berseem fodder in maunds per acre.

Basic manure	Plot No.	No manure	Bone meal 120 lb. P_2O_5	Ammon. phos. 120 lb. P_2O_5	Superphos 120 lb. P_2O_5	Bonemeal 60 lb.+ Am. Phos. 60 lb. P_2O_5	Bonemeal 60 lb. plus Superphos 60 lb. P_2O_5
Nil	8—c	140	173	263	144	192	162
Green manuring with S. hemp	13—F	188	208	316	227	262	224
Raw Farm Yard manure at 10 tons per acre	7—F	387	440	528	425	502	455

Owing to late supply, superphosphate was applied one month after the other fertilisers and hence its comparative lack of response has been inevitable.

(c) Other Manurial Experiments

(i) *The manurial values of ammonium nitrate alone and in combination with* 1, 2 *and* 3% *T.N.T.*—These experiments were conducted at the suggestion of the War Department in order to assess the manurial values of these substances, large quantities of which are likely to be available after the war. Trials with paddy and sugarcane were taken up at Karnal and with sorghum, cotton and wheat at New Delhi. Although the ammonium nitrate and its mixtures with T. N. T. showed no differential response, the yields of crops from these treatments were not significantly different from those obtained from the sulphate of ammonia treatment, indicating that ammonium nitrate as well as its mixtures with T.N.T. had no harmful effects and could be used like sulphate of ammonia as efficient nitrogenous manures.

(ii) *The manurial values of Oklanite, Digested and Activated sludge in comparison with those of other organic manures and fertilisers.*—These experiments were started during the year at the instance of the Government of India. The experiment was sown late on December 9th & 10th. The yield of Peas, I.P. 29 from the 'no manure' plots was 19.9 maunds per acre and those from other treatments in maunds per acre were Oklanite—18.8, Digested sludge—18.6, Activated Sludge—20.2 and superphosphate—21.1. The manures were applied at 80 lb. P_2O_5 per acre. In the case of barley, however, the yields of grain were: from the 'no manure'—24.2, Oklanite—37.2, Digested Sludge—34.5 and Activated Sludge—33.6, but 39.4 maunds of barley per acre was obtained from Sulphate of ammonia at 80 lb. N. This suggests that the organic manures when applied late do not respond as efficiently as the mineral fertiliser in Delhi soils. This is further confirmed by another experiment which was laid out in a soil of poor fertility and in which wheat I.P. 165 was sown late after a heavy crop of sorghum. The yields of wheat grain were: 'no manure'—12.3, Oklanite—12.5, Digested Sludge—11.8, Activated Sludge—13.1 and H.A.F. (Prepared by the Sci. & Indus. Res. Lab. Delhi)—11.6 maunds per acre respectively, the yields from the artificial fertilisers, were significantly higher and were sulphate of ammonia—22.5, Amatol—25.5, Ammonium nitrate with 2%—18.0 and with 3% T.N.T.—30 maunds per acre approximately. The results indicate the value of a readily available fertiliser in a late sown crops in a depleted soil at Delhi.

(iii) *Effect of sulphate of ammonia in one or more doses on the yield of wheat.*—The yields of what C. 518 were: 'No manure'—26.6, sulphate of ammonia in one dose of 30 lb.—32.4, in two doses of 15 lb. each—30.0 and in three doses of 10 lb. each—33 maunds per acre. The manured crops had lodged more than the unmanured and hence the results were somewhat masked.

(iv) *Comparative manurial value of farm yard manure prepared by different methods.*—High yields of wheat C. 518 were obtained this year ranging from 26 to 40 maunds per acre, but the differential responses of the manures were not statistically significant.

(v) *Manurial experiment at Karnal with paddy followed by berseem.*—A new experiment was conducted at Karnal with paddy manured with bonemeal, farm yard manure and sulphate of ammonia and certain combinations of these manures. Unmanured berseem followed this manured crop of paddy. Bonemeal at 120 lb. gave an increase in the yield of paddy of 10.5% and bonemeal in combination with F.Y.M. at 40 lb. N produced an increase of 21.6% over the control; sulphate of ammonia at 40 lb. N gave an increase of 18.1%

whereas sulphate of ammonia in combination with bonemeal produced an increase of nearly 29%. The increases in the yields of green berseem following paddy ranged from 0.28 to 18.08 per cent over the yields of the unmanured plot, but the differential response of the manures was not statistically significant.

(d) Green manuring experiments at Karnal

(i) The results of the experiments with leguminous and non-leguminous green manure crops, with and without artificial fertilisers, confirm the previous findings that the leguminous crops, sunnhemp and cowpeas are more effective than the non-leguminous crops, maize and sorghum in increasing wheat yields, both grain and straw and that green manuring with sorghum invariably depresses the yields to a level even lower than that from the 'no manure' control. In previous years, Superphosphate when applied at the time of sowing or burying the green manure crop has always showed some effect with the legumes but none with the non-legumes, whilst ammonium sulphate applied at the same time showed its effects than Superphosphate with legumes as well as non-legumes. This year, the sulphate of ammonia has had more effect.

(ii) To a field green manured with sunnhemp artificial fertilisers were applied. The yield of wheat I.P. 4 from the green manured plot alone was 14.2 maunds, that from sulphate of ammonia at 40 lb. N was 14.7 maunds and from superphosphate at 80 lb. P_2O_5 treatment was 15.3 maunds per acre, whereas those from the plots manured with a mixture of these fertilisers at 40 lb. N plus 80 lb. P_2O_5 averaged 20.9 maunds; the addition of sulphate of potash to this mixture at 50 lb. K_2O_0 produced a yield of 20.8 maunds per acre.

(e) Flood water Farming experiments

These experiments were repeated both at Delhi and Karnal. Due to good and well distributed monsoon rains and their extending up to October flooding the land in August and September or in September only, did not show increased outturns of crops this year. In fact, the yields of crops this year were higher in the rainfed series than in the flooded series. This seems to be due to the loss of some nitrogen by the irrigations given late in the season, when only partial recovery of this nutrient was possible. In the case of oilseeds such as *sarson, toria, taramira* and linseed, increases extending up to 5 maunds per acre were obtained from the flooded series over the rainfed series.

(f) Cultivation experiments at Karnal

Ploughing with Victory plough supplemented with country ploughs gave higher yields of wheat, I.P. 165 than ploughing with tractor ploughs, whereas the lowest yields were obtained from the plots ploughed with country ploughs alone. Yields from the plots manured with farm yard manure and with sulphate of ammonia, each at 40 lb. N per acre were similar, but those from fields manured with a combination of these two manures at a total dose of 60 lb. N, were decidedly superior in all the cultivation treatments. The yields in general were at a very low level due to unavoidable late sowing.

(g) Mixed farming experiments

These were continued in a 8-acre holding at Delhi and three holdings of 8, 25 and 400 acres at Karnal.

(h) Mulching experiments with sugarcane, etc.

These experiments were continued at Delhi and Karnal and again showed the beneficial effects of artificial mulching with cane trash in producing a higher tonnage of cane from the mulched than the unmulched fields.

(i) Collection of fodder grasses

At Delhi the field collection of 70 species of indigenous grasses was maintained and a few new grasses were added to it.

(j) Experiments of other Sections of the Institute

Necessary facilities were provided both at Delhi and Karnal to the other Sections of the Institute for carrying out certain field experiments.

AGRICULTURAL SUB-STATION, KARNAL

1. *Season & Crops.*—The season on the whole was unfavourable. The rainfall from June, 1944 to May, 1945 was 21.57 inches, much below normal, against 22.79 inches recorded last year. Most of the *Kharif* sowings started with the rains and crops suffered badly owing to heavy downpours soon after sowing during the month of July. During August, there were only 3 inches of rain, out of which 1.2 inches fell on the 30th. The month was too dry for favourable growth of crops in general and fodders in particular. September rains, which are so necessary both for the standing crops of *kharif* and the sowing of *rabi*, were all received on the first and the fourth of the month, the rest of month was dry. This resulted in the hastening of the harvest of fodders in order to sow gram on the residual moisture. Pulses and other grain crops sown 'barani' suffered a good deal due to early cessation of rains. Winter, except for 2.08 inches of rain in January, was practically dry and *barani* (rainfed) crops suffered. In March, unusual weather prevailed in the early part of the month there was a sudden fall of temperature, while in the end of the month, the temperature rose very quickly accompanied by strong westerly winds. The cold wave affected the grain formation in gram and other pulses and a number of plants remained with empty and unfilled pods at harvest. There was considerable shrivelling of grain thereby reducing the yields particularly in the late sown crops.

2. *Cultivation.*—The condition of tillage equipment further deteriorated, with the result that hot weather and rainy season cultivation which are so important for suppression of weeds could not be carried out to the required extent and both the *kharif* and *rabi* crops suffered in consequence. Fields had to be cleaned vigorously at the time of seed-bed preparation in rabi which delayed the sowing and ultimately resulted in the low yields.

3. *Manuring.*—The only source of manure is from cattle which, under the present system of management, can hardly fertilise about 50 acres per year as the rest goes to the grass-land. Green manuring is also practised but due to erratic rainfall and shortage of irrigation water it cannot be taken up on a large scale. No other manure is used for crops in general. The land is getting impoverished year by year and the fertility has stabilised at a lower level with a consequent decline in yields. Continuous and systematic manuring for some time is required for higher yields.

4. *Irrigation.*—All the area under direct cultivation (except 50 acres controlled by the direct outlet) is irrigated by one Minor with a discharge of 7.13 cusecs. Water is especially scarce in early *kharif* and *rabi* when it is supplied strictly in accordance with rotational turns of about 8 days in a month. Though money for the installation of two tube wells has long been sanctioned the work has not been taken up so far due to war-time difficulties. The shortage of water is a contributing factor to yields.

A new seasonal outlet in no. 7 with a discharge of 4 cusecs was constructed and used during the year. Water from this outlet can be had only during the monsoon when it is surplus in the canal. A large area was irrigated by this out-let for developing the flood-water-farming experiment on large scale based on September irrigation. Though the winter was comparatively dry and no irrigation was given, satisfactory yields were obtained. The farm suffers from shortage of funds. The budget provision does not meet the needs. During the war, prices of material and wages of labour are several hundred per cent above the pre-war level but the budget provision is unchanged. The total expenditure per acre over the area under direct cultivation comes to about Rs. 40 only. With this amount only extensive methods are possible. No money is left to be spent on other important items in connection with improvement of the estate which remain neglected. The expenditure per acre on other farms is more than double this amount.

Due to lack of funds, new bullocks could not be purchased. The strength declined from 90 to 70.

5. *Machinery.*—As anticipated in the previous report the condition of machinery has gone from bad to worse, there was no improvement in the situation in regard to either the procurement of new machines or spare parts. The old machines which have out-lived their estimated lives could not despite all possible efforts, be kept in working order. One, out of the three old tractors could not be worked at all as it is beyond repair. The same was the case with threshers, choppers and mowers and other implements.

There was no improvement in the coal situation during this year. Large quantities of wood had to be used as fuel for the Steam Tackle plant. This has resulted in raising the cost of operations considerably. But owing to the lack of alternative form of power, it was put into use in ploughing etc. The steel cable is worn out but after a great effort a new steel rope was purchased at a cost of Rs. 3391. The plant worked for 470.50 hours with the plough, discharrow and grubber during this year.

6. *Tractors.*—Of the two McCormick Deering W.D. 40 tractors purchased in the year 1936 only one, No. 1612 worked during the year under report. The other No. 1614 went out of order due to the lack of spare parts and did not work at all. With the change of parts from one to the other, tractor No. 1612 could work for 1337.50 hours during year. The cost of working was Rs. 2.93 per hour.

The McCormick Deering Diesel tractor no. 9962 which was purchased in 1940 worked for 901.56 hours. The cost per hour has gone to Rs. 6.04 due to replacement of parts this year.

7. *Cropping plan.*—This was more or less on the same line as last year. The three mixed farming holdings of 400, 25 and 8 acres respectively were worked according to plan.

The Rohtak-Sirsa *jowar*, which is thin and palatable and has been tried as fodder for some years, has been proved a poor yielder. This variety needs to be replaced with the same old 'Purbi' *jowar* which has given good yield in the past.

For some years we are trying to grow *kharif* grain-crops on a sufficient scale on the farm. Most of these, except paddy, are grown under rainfed condition due to limited water.

Besides delayed, *rabi* sowing 'wilt' in gram was also responsible for reduced yields. In certain places the mortality was almost cent per cent while on an average it was 55% particularly in block 5 where gram was sown on an extensive scale.

8. *Incidence of pest and diseases.*—The kharif crops were genearlly free from disease except sporadic attack of insect in paddy.

Wilting of gram crop was very severe this year on the farm. In block No. 5 where gram was grown on an extensive scale the intensity of wilt on an average estimated to be as high as 55.5%, at places the mortality being almost cent per cent.

Though barley and oats were sown with seed treated with formaline but the treatment did not prove to be effective perhaps due to the poor quality of formaline obtained from Lahore.

All the wheat varieties were found to be absolutely free from 'bunt' this year and the incidence of rust was also very low. Loose smut was observed in almost all the varieties but in Black rust occurred in I.P. 165, but was negligible in extent.

9. *Experiments.*—Details of experiments in progress and the results obtained are given in the main report under the head "Field Experiments". The following experiments were carried out for other sections during the year 1944-45. 1. Cotton expt. for 'Population studies'. Entomology Section. 2. Linseed cultures to study the rust resistance. Botany Section. 3. Sugarcane for the Pyrilla control expt, Entomology Section, 4. Sugarcane for red rot expts. of Plant Pathologist. Mycology Section, 5. Barley for control of smut of Mycology Section.

10. *Improvement.*—For want of equipment, the work of levelling and grading could not be taken up. Unless the farm is properly levelled, yield of crops will continue to suffer due to water logging and ill distribution of canal water.

11. *Seed Supply.*—Seed multiplication of I.P. varieties was continued during the year. Fewer orders for the varieties available with us were received perhaps due to the transport difficulties. Wheat, peas, paddy, cowpeas and gram seeds, about 57 maunds, were supplied to different places in the country.

12. *Hay-making.*—This has now formed a routine practice on the Farm and large quantities of berseem hay of satisfactory quality for feeding the cattle were made. The technique of its manufacture also remained under study.

13. *Usar (alkali).*—The method of covering alkaline patches with mulch was continued. The results of experiment in No. 6 have indicated that the movement of salts can be controlled when adequately covered with artificial mulch instead of leaving the surface bare and exposed.

14. *Compost.*—As mentioned in the last report, the manufacture of compost is not carried out on a large scale. The dung is carted direct into the fields and ploughed in Statement showing analysis of cost of the compost made this year is given below:—

Statement of compost making during the year 1944-45

Name of Block & pit No.	Balance of compost on 1.7.44.	Manufactured during the year.	Balance in hand on 30 5.45.	Carting charges from 1 7.44 to 10.12.44.		Turning charges.		Total cost.		Cost per md.		Remark
	Md.	Md.	Md.	Rs.	As.	Rs.	As.	Rs.	As.	As.		
No. 7 pit No. 11	1800	—	—									From 11th December, 1944 dung was carted direct to the field continuously.
No. 4 pit No. 11	800	4400	4400	407	8	80	2	487	10	1·3		
5E, road side pits	8000	1595	4000									
Total :—	10600	5995	8400									

15. *Educational Training.*—The Sub-Station serves as a training centre for different advanced cources. This work has to be managed with the existing staff each of whom has already heavy routine duties on the farm.

The following courses were held.—1. Advanced course in Animal Husbandry—29th January to 17th February, 1945. Eleven students joined this course and received training in mixed farming and cattle breeding.

2. Post Graduate course of Imperial Dairy and Research Institute, Bangalore—1st February to 9th February, 45. Two students joined this course at Karnal and received instruction in mixed farming and breeding of cattle.

3. Post graduate course in Agriculture of I.A.R.I.—3rd April to 15th May 1945. Eleven students joined to continue this course at Agricultural Sub-Station, Karnal. They received training in mechanised cultivation, mixed farming and general agriculture.

16. *Programme of work.*—Details are given at the end of the report.

II. CATTLE BREEDING

(Delhi and Karnal)

1. *Herd Strength.*—At the end of the year the strength of the Sahiwal herd at Delhi and the Tharparkar herd at Karnal was as follows:—

Animals	*Strength at Delhi*	*Strength at Karnal*
Stud bulls	14	19
Milch cows	93	99
Young female stock	80	92
Young male stock	104	98
Total ..	291	308

2. *Cattle disease and mortality.*—The Sahiwal herd suffered from an outbreak of Black Quarter in March, 1945, 2 cases of Anthrax of which only one was confirmed and an outbreak of Foot and Mouth disease at the end of June, 1945. There were 13 deaths among adult cattle and 7 deaths among calves under the age of three months, most of the deaths among adult were due to Black Quarter. The mortality among calves was less than that in the previous year.

In the Tharparkar herd foot and mouth disease in severe epidemic form broke out towards the middle of May, 1945. The number of animals affected being 43 cows in milk, 5 pregnant animals, 31 young female stock, 17 young male stock and 38 bullocks. The situation was brought under control without any mortality, but many high yielding cows dropped in yield. The general condition of the herd deteriorated considerably. There were sixteen deaths during the year, comprising of 1 cow, 1 served heifer, 8 young female calves and 6 young male calves. The cow referred to had an abortion and after ailing for some time it died with certain complications. Calf pneumonia was the chief cause of loss of calves.

3. *Milk Yields.*—The daily average milk yield for the year of the Sahiwal herd was 20.4 lb. and of the Tharparkar herd it was 20.17 lb. The daily average overall yield was 14.9 lb. in the Sahiwal and 13.6 lb. in the Tharparkar. The percentage of cows in milk was 72.9 in the Sahiwal and 67.1 per cent in the Tharparkar herds.

4. *Early maturity experiments.*—The long term experiments on early-maturity, handling, weaning, and 4-times milking were continued both at Delhi and Karnal. In the Sahiwal herd 37 heifers at an average early age of 1 year, 7 months and 12 days were bred to bulls on an average live weight of 627 lb. The average age of calving of 21 heifers which completed lactation during the year was 2 years and 4 months with an average calving weight of 824 lb. Their average lactation yield was 4999 lb. in 282 days. The daily rates of gain of these early maturity heifers at service age, calving age, and closing lactation age were 1.1 lb. 0.91 lb. and 0.71 lb. respectively.

5. *Calf rearing on standardised milk.*—At Delhi the calves were weaned and reared on milk standardised to 3.5 per cent fat and showed a much better growth than those of the previous year which were also fed on the same system. The sex ratios of calves born was 63.3 per cent males and 36.7 per cent females with an average birth weight of 54 lb. for males and 52 lb. for females.

The Tharparkar calves at Karnal were also weaned and reared on Standardised milk.

The offspring of Tharparkar bulls Pathan, Hakim, Jung and Balwant have been predominantly males, whereas those of bulls Faisal, Tika, Ezaz and Sikandar have been predominantly females. Alam and Inam have given equal numbers of male and female calves.

6. *Rationing of stock.*—Due to difficulties in getting cattle feed the proportions and ingredients of the concentrate ration of the cattle had to be changed several times during the year, and the nutritive ratios of the concentrate ration ranged between 1:2.5 to 1:4.5, The standard ration, containing 35% oats, 30% gram, 15% groundnut cake, 10% linseed cake and 10% bran has a nutritive ratio of 1:3.3.

III. RESEARCH PROGRAMME FOR THE YEARS 1945-46 AND 1946-47

A. Agronomy

(1) *Scheme for the Development of Research*

1. Manurial trials to determine the relative values of nitrogen in different organic manures and inorganic fertilisers and the estimation of their recovery by the crops and the changes brought about in the soil will be continued in collaboration with the Imperial Agricultural Chemist in,

(i) The old series with the addition of minor elements in certain blocks. and

(ii) The new series which will include green manuring.

(2) *Agronomic experiments under the charge of the Imperial Agriculturist*

(a) *Manurial trials*

(i) Further development of the results of previous experiments on the phosphate manuring of legumes and their direct and indirect effects on succeeding crops.

(ii) Paddy manurial experiments at Karnal including the experiments with sulphate of ammonia, farm yard manure and bonemeal and their combinations and followed by berseem.

(iii) Effect of dipping paddy seedlings before transplanting in mixtures of night soil, ash and ordinary soil as well as in mixtures with other manures.

(iv) Effect of ammonium nitrate alone and in combination with different percentages of T.N.T. on sorghum, cotton and wheat at Delhi and paddy and sugarcane at Karnal.

(v) Manurial trials with Oklanite, Digested sludge, Active sludge, etc. with barley, wheat and peas. and

(vi) Manurial trial with grasses, lucerne and other crops.

(b) *Green manuring experiments*

(i) Green manuring experiments with sunnhemp grown *in situ* and that brought from outside as suggested by the Government of India.

(ii) Green manuring experiments with sunnhemp grown *in situ* and that brought from outside, with and without the addition of fertilizers.

(iii) Green manuring experiments with indigo and other leguminous crops at Karnal and with phosphate manured indigo at Delhi.

and (iv) The effect of artificial fertilisers added to green manure in wheat at Karnal.

(c) *Cultural experiments*

(i) Tillage experiment at Karnal to test the relative merits of tractor ploughs and bullock drawn iron and wooden ploughs in tillage operations required for the cultivation of wheat.

(ii) Cultivation experiment at Karnal with paddy with tractor ploughs and country ploughs as suggested by the Government of India.

(d) *Mixed Farming experiments*

(i) Continuation of the experiments in holdings of 400, 25 and 8 acres at Karnal and with an 8-acre holding at Delhi.

(ii) Continuation of the experiment in two small holdings at Delhi with 50 and 66 per cent intesities of green manuring.

(e) *Mechanised Farming Experiments at Karnal*

These will be continued on the lines followed in previous years.

(f) *Flood water farming experiments.*

Continuation of the work in progress at Delhi and Karnal on experimental scales and on a 300-acre large holding at Karnal.

(g) *Mulching experiments with sugarcane, etc.*

These will be continued on the lines adopted in previous years. The effect of mulch cover in relation to the movement of alkali soils is also being studied.

(h) *Collection of Fodder grasses*

Maintenance and fresh collections of indigenous grasses will be continued

(i) *Crop weather observations*

The correlation of certain agronomic characters of wheat and sorghum with weather factors will be studied.

(j) *Experiments of other Sections of the Institute*

This will be continued as in previous years.

(k) *Cultivation of seed potatoes at Karnal for the distribution of disease free material*

This work will be started in 1945-46 in collaboration with the Plant Pathological Section.

B. BREEDING HERDS

(1) Handling of Sahiwal and Tharparkar stock for the development of "milk temperament".

(2) Feeding of stock on a balanced ration for growth; early maturity, high milk production under 4-times milking, based on a narrow ration of 1:3.5 to 1:4.0 according to Morrison's feeding standard.

(3) Four-times milking as means of stimulation of high milk yield in Indian milch cattle.

(4) Premilking.

(a) As a means of stimulation for milk secretion.

(b) To train heifers to milk before they actually calve.

(c) To prevent malformation of the udder.

(5) Early maturity treatment.

(a) To prove milk capacity of heifers before 4 years of age.

(b) To test bulls for transmitting capacity of high milk yield before the age of five years.

(c) Mating heifers to bulls on a standard size of 2|3 adult live weight (600 lb.) irrespective of any age below 2 years.

(6) Calf rearing on standardised milk, based on a scale 1|10th of birth weight for an even rate of growth, as a measure of control against scouring in calves in the early weeks of their lives due to high percentage of butter fat in the whole milk.

IV STATISTICAL BRANCH

(P. V. Krishna Iyer)

1. DAIRY DATA (1904—1932)

Age at first calving for the period 1904-32.—In the beginning the age at first calving was 41 months, later it was 44-46 months and subsequently it came down to 36 months. The average age at first calving since four times milking and early maturity experiments were started was about 29 months. It is thus clear that heifers bred in dairy after 1932 were maturing about 7 months earlier than in the pre-experimental period.

Total milk yield.—The cows belonging to the second, third and fourth progenies have shown some improvement in the yield over the purchased and first progeny cows in the fourth and fifth lactations, which is the period at which the yield reaches its maximum. The average yield in the various progenies and lactations lie between 2553 ± 156.9 lb. and 4361 ± 562.1 lb.

Wet average per head per day.—The cows of the second, third and fourth progenies have in general done better than the purchased and first progeny cows in the third or fourth lactation. In the second lactation also they have practically given the same amount of milk as their previous progenies. In general there is no significant difference between wet average yields for cows of the second and subsequent progenies and they have done better than the purchased and first progeny cows. The averages varied between 9.61 ± 0.50 lb. and 13.83 ± 0.70 lb.

Average overall milk yield.—The differences between the averages whether between lactations or progenies are not significant. Unlike the wet averages there is no improvement in the overall averages in the second and subsequent progenies in any of the lactations. The overall averages in the different lactations fluctuate between the values 5.67 ± 0.27 lb. and 9.35 ± 1.02 lb.

Average wet period.—The differences in the wet periods are not in general significant. Excluding the second, third and fourth lactation of the purchased cows and the second lactation of the fifth progeny, the wet periods vary between 267.4 ± 13.45 and 300.5 ± 6.18 days. For the purchased cows the wet period is maximum for the second and fourth lactations and is 329 days. The wet period for the second lactation of the fifth progeny cows is less than the other cases and is 239.9 ± 24.46 days.

Average service period.—The service period does not appear to have been affected by the age of the cows. The averages for the various lactations and progenies lie between 145.9 ± 31.05 and 266.8 ± 41.08 days.

Average dry period.—There is considerable variation between the dry periods of the different progenies in various lactations. The average dry period is near about 200 days or more in the majority of cases.

Influence of season of calving on milk yield.—In general the yield of cows calving in July, August, September and November appears to be slightly less than those calving in the other months.

Optimum service period for maximum milk production.—On the basis of lactation curves for four times milking for the periods calving to service and service to drying, it has been found that the milk yield for a lactation of 305

days is a maximum if the service period is about 11 weeks. The milk yield is maximum for life time, it the service period is near about 7 weeks, the lactation period being 305 days.

Birth weight of calves under four times milking.—Calves of the heifers weigh about 3 to 6% less than those of the adults. The differences between weights of the calves of the different generations are not significant for any of the calvings. The male calves weigh 4 to 12% more than the female calves. The average birth weight of the male and female calves at first calving vary from 47.97 ± 1.22 to 49.48 ± 1.50 lb. and 43.53 ± 0.87 to 46.21 ± 1.02 lb. respectively in the first three generations. In the second, third and fourth calvings the average weight of the male calves vary from 51.25 ± 1.23 to 59.60 ± 3.47 lb. For the female calves the variation in the average birth weight extends from 47.00 ± 2.12 to 49.90 ± 1.54 lb.

The correlation between the weight of the mother and its calf is not on the whole significant for any of the calvings or generations.

Growth studies of cows.—From calving to service the cows loose in weight at an average rate of 0.95 to 6.62 lb. per week. It is less in the first lactation, intermediate in the second and third lactations and more in the succeeding ones. From service to date of drying they gain in weight at an average rate ranging from 1.58 to 3.88 lb. per week. In the dry period they steadily continue to gain in weigth at a rate which ranges from 5.10 to 8.20 lb. per week. The differences between these increases are not significant for any of the lactations. Hence the gain in weight during the dry period can be considered to be the same for all the lactations.

The effect of symptoms of Johne's disease on milk yield and weight.—Comparing the values of average weekly milk yields and weight in different lactations and also the average rate of increase or decrease in the yield and weight between the dams and daughters, daughters showing symptoms of Johne's disease, it has been found that the differences between the milk yields and weights for the dams and daughters are not significant either before or after service. However, the average weight of the dams in the dry period after the close of the first lactation is 130 lb. more than their daughters. This difference is on the verge of significance at the 20% level. The weekly rate of increase in the growth of dams is 1.35 lb. more than that for the daughters.

2. TIME REQUIRED TO PLOUGH AN ACRE WITH COUNTRY PLOUGHS

The time and the draw-bar-pull required to plough one acre of land with the Delhi and Bankura ploughs were much less than that required for ploughing with any of the other ploughs. In the case of Delhi and Bankura ploughs the time required was 10 hours while for the other ploughs it varied from 11 to 13 hours.

3. WATER LEVEL READINGS

Fortnightly readings of the depth of the water level in the different wells of the Institute show that the rise in the level since 1940 varies from 7 ft. to 13 ft. 3½ inches in the various wells.

4. THEORETICAL INVESTIGATIONS

The relation between the generalised variance of a multivariate population and the residual variance from the regression equations has enabled me to obtain the distribution of Hotelling's T^2 and the ratio of the generalised variances between any number of samples and the total for all the samples. The results obtained have been published in Curr. Sci. July, 1945, issue and the Proc. of the Ind. Acad. of Sci. August, 1945 issue.

5. MISCELLANEOUS

Assistance was given to the different Sections in drawing up layouts of experiments and in analysing and interpreting their data as and when required.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(Dr. B. P. Pal)

I. RESEARCH.

1. *Study and Improvement of Indian Wheat* (Triticum sp.)

(i) *Survey of Indian Wheats.*—The study of the all-India collection of samples of wheat was continued with a view to confirming the previous years' observations. Thirty five wheats were added to the collection. The comparative study of 200 wheats grown at Delhi, Pusa and Coimbatore was also continued. At Simla, the study of hill wheats was continued.

(ii) *Description and registration of commercially important varieties and those of special interest for plant breeding.*—The varieties of wheat under study for registration were grown and described in great detail with a view to finally confirming the previous observations.

(iii) *Study of wild and cultivated wheat species and allied plants.*—The F_5 generation of the intergeneric hybrids, *T. vulgare* × *Secale cereale* and *T. vulgare* × *Aegilops caudata* was studied and promising plants possessing valuable characters, like high tillering, long ears, amber and red-coloured well-filled grains and high resistance to rusts were isolated and selected. In some of the F_5 generation progenies of the cross *T. vulgare* × *Ae. caudata* a few plants resembling *T. sphaerococcum* were noticed. Such plants were also observed to occur during the previous year in some of the F_4 progenies of this cross. These observations are interesting from the point of view of the origin of *T. sphaerococcum.*

The collection of grasses allied to *Triticum* was under study. Several new additions were made to the collection from the material received from abroad.

The study of the mode of inheritance of the branched ear, the 'extra-glume' and the colour of glumes was continued in the crosses of *T. Vavilovi* with *T. vulgare* and with *T. sphaerococcum.*

(iv) *Experiments on smut resistance.*—The testing of varieties, including new strains of hybrid origin, for resistance to loose smut, was continued, in co-operation with the Mycology Section. As in the last year, quite a large number of the new strains proved to be resistant.

(v) *Breeding for rust resistance.*—This work is carried out in collaboration with Dr. K. C. Mehta. Tests of varieties and hybrids for both seedling and adult resistance were carried out at Simla*, and for adult resistance only, at New Delhi. Most of the hybrids from the brown and yellow rust crosses, now in the F_{10} generation, are pure for resistance to these rusts, thus confirming last years' results. The two black rust crosses were in the F_6 generation; although still segregating, some of the cultures are now nearly pure for resistance to this rust. It was mentioned last year that in order to unite

*At the Potato and Wheat Breeding Sub-station, financed by the Imperial Council of Agricultural Research.

resistance to all the three rusts, a double cross had been made on a large scale. Nearly 2000 plants from this cross were tested for resistance to all the three rusts, in both the seedling and the adult stages. In the seedling stage resistance to yellow rust was dominant while in the case of the other two rusts susceptibility was dominant. In the adult stage susceptibility appeared to be dominant in the case of all the three rusts. Selections were made for further breeding work.

(vi) *Miscellaneous.*—The collection of wheats from Baluchistan and Persia was maintained and studied. F_1 hybrids of crosses, between Baluchistan varieties and some of the improved strains were grown and studied. It is proposed to sow a part of the F_2 seeds in Baluchistan and make selections under conditions obtaining there.

2. *Breeding for Disease Resistance and other Qualities.*

(i) *Potatoes* (*Solanum tuberosum* L. and *Solanum* spp.).—At New Delhi, a number of hybrid cultures were grown and studied and selections made for yield and disease resistance. It was, noticed that some hybrid cultures, being the earliest in maturity, were the least affected by ground frost and yielded a fine crop of tubers of good size, shape and colour. Twenty-four promising hybrids were put under a preliminary yield trial along with the varieties *Phulwa, Gola,* and *Darjeeling Red Round.* Of these, 13 have been selected for further trial.

At Simla, the breeding of varieties resistant to late blight and other diseases was continued. The trials of new hybrids evolved at Simla were continued at a number of centres in the Provinces and States. Some of the new varieties have given very encouraging results.

At the Intermediate Hill Station at Bhowali promising hybrids were multiplied for trial under plains conditions.

(ii) *Pigeon Pea* (*Cajanus Cajan* (*L*) *Millsp.*).—The work of testing and selecting wilt-resistant strains from among the progenies of the cross I.P. 24 × I.P. 51 was further continued at Delhi and Pusa with the co-operation of the Imperial Mycologist. These selections will be tested along with some of the promising Indian and Burma material under conditions of artificial infection in the field at both places.

(iii) *Linseed* (*Linum usitatissimum L.*).—The selection of strains resistant to linseed rust (*Melampsora lini*) was continued at Delhi and Karnal. While the incidence of rust was negligible at Karnal during the year under report, that at Delhi was again heavy. Here, only 4 out of 110 rust-resistant cultures were only slightly infected, the others as well as the resistant exotic parent were free from the disease; all the I.P. types and other cultures were affected to varying degrees. All the 10 promising rust-resistant cultures grown at Pusa were free from the rust whereas all I.P. types and other cultures were affected.

Dual-purpose strains from linseed-flax hybrids were grown at Delhi and Pusa. The fibres obtained are awaiting technological evaluation by experts.

(iv) *Tobacco* (*Nicotiana spp.*).—The collection of Nicotiana species was maintained and studied. A number of them were again grown at Delhi, Pusa and Guntur to test their reaction to *Orobanche*. The previous year's observation viz., that although all the species were attacked by the parasite some withstood the attack better than others, was confirmed.

The frost-resistant species and hybrids were grown at Simla and studied. The interspecific hybrid, *N. Tabacum* × *N. quadrivalvis*, was observed to be completely sterile.

The F_6 progenies of the large numbers of selections made from intervarietal crosses in *N. rustica* were grown and studied for growth, vigour, leaf size, colour, puckering and maturity. Some of the selections appeared to be superior to I.P. 18, the local type. These will be further tested.

The F_6 progenies of the various cigarette tobacco crosses were grown at Pusa and further selections were made.

The manurial and rotational experiments in respect of yield and quality of leaf in cigarette tobacco were continued at the Sub-station Tobacco Research at Guntur*. The newly-evolved variety Amarelo 5 has proved to be very successful and, in many respects, superior to Harrison's Special. Strains showing considerable resistance to mosaic have also been obtained from the cross Harrison's Special × Ambalema.

3. *Cytogenetical Studies in the Brassicae.*

(i) *Classification.*—The large number of types of the cultivated *Brassicae* collected from all over India, were again studied from the morphological, genetical and cytological standpoints. A number of varieties brought from China were also grown and studied.

Studies on the experimentally-synthesised *B. juncea* were continued from the point of view of their variability, sterility and crossability.

(ii) *Genetical studies.*—The study of the inheritance of self-sterility in *toria* (*B. campestris* var. *toria*) was further continued with inconclusive results. The apetalous character was confirmed to be controlled by a single recessive gene subject to the influence of modifiers. Crosses between tetraploid forms of apetalous and petalled plants were also under study. The inheritance of the mucilaginous character of the seed coat was also under study in a cross between the apetalous mutant (brown-seeded, mucilaginous) × yellow *sarson* (yellow seeded, non-mucilaginous). It was found in the F_2 that mucilage was recessive to no mucilage and yellow seed to brown seed, each on a monogenic basis. When the two characters were taken together, it was observed that the combination yellow seed coat and mucilage was absent in the F_2 although the combination brown seed and no mucilage, and the parental combinations were obtained; further studies are in progress. Studies on the mode of occurrence of apomixis in both self-fertile and self-sterile species of *Brassica* were continued.

*Financed by the Imperial Council of Agricultural Research.

(iii) *Artificial induction and study of polyploids.*—Large populations of the colchicine-induced tetraploids of *B. Nigra, B. Campestris,* (*toria* and *sarson*), *B. Tournefortii* and *Eruca sativa* (*taramira*) were grown and studied with regard to growth, vigour, morphological characters, cytological behaviour, fertility and crossability as compared to the corresponding diploids. Promising plants with increased fertility and vigour were selected. A detailed study of a large population of tetraploid *toria,* comprising over 7000 plants, has shown: (i) the average fertility of the population had increased owing to selection and that some plants were as fertile as the diploids; (ii) the extent of natural crossing between tetraploid and diploid forms was again negligibly small; the former, however, when grown in the vicinity of diploid *B. juncea* (ordinary *rai*) crossed more readily with the latter than the diploid and (iii) the seed size remained considerably bigger than that of the diploid.

Progenies of intervarietal crosses between tetraploid forms were found to be very much more fertile than those of intravarietal crosses; they also possessed marked vigour with bigger pods and seeds than the diploids. A number of promising selections were made.

4. *Fundamental Cytogenetical Research.*

(i) *Colchicine-induced polyploids of crop plants.*—Autopolyploids of various crop plants were under study in different generations with a view to evaluating their usefulness for breeding purposes. The C_7 generation of the tetraploids in gram (*Cicer arietinum* L.) and chilli (*Capsicum annuum* L.), and the C_3 generation of *Sesamum orientale* were grown and studied with regard to growth, vigour, fertility and other economic characters in comparison with their corresponding diploids and promising plants were selected. Selection for improved fertility through seven generations in the case of gram and chilli has not proved to be effective. The tetraploid *S. orientale* was found to be as efficient as its diploid as regards growth, branching and the number of capsules per plant, but the capsules yielded a very small percentage of viable seeds. Crossability between diploid and tetraploid forms of *S. orientale* in relation to growth of pollen tube in the stylar tissue and development of the embryo was studied. A technique of dissecting out embryos was evolved by which the different stages in the embryogeny of *Sesamum* could be studied quickly and easily.

Besides the autopolyploids, the amphidiploids of *Sesamum* and *Nicotiana* were also studied. A large number of A_3 progenies of the amphidiploid, *S. indicatum,* was grown and studied with regard to their morphology, cytology and fertility. The progenies were found to be fairly uniform morphologically but were pollen-sterile to varying degrees in spite of regular meiosis in them. They were highly female fertile under conditions of open pollination, but produced, besides some viable seeds, varying percentages of 'developed ovules' containing no embryo within. The cause of occurrence of the developed ovules is under study.

An interesting feature of the amphidiploid was the spontaneous occurrence in its progenies of a number of sterile plants (about 5%) of parthenogenetic

origin. These plants were of the constitution of the hybrid (*S. orientale* × *S. prostratum*). The cause, of their occurrence is under investigation.

The cytology of the *glauca plumbagenifolia* amphidiploid, (2n = 44) was studied. The amphidiploid having proved completely malesterile, fresh crosses between the two species were made using different varieties with a view to obtaining more amphidiploids.

(ii) *Collection and study of wild relatives of cultivated plants.*—The collection of wild and allied species of crop plants was maintained and several further additions to it were made. They were under close observation with regard to the useful genes contained in them. The suitable among them were hybridised with the cultivated species. The following are of particular interest.

(a) *Sesamum orientale* (2n = 26) × *S. prostratum* (2n = 32).—The A_3 generation of the amphidiploid, tentatively designated as *S. indicatum,* and its back-crosses to each of the two parents were studied morphologically and cytologically. By suitable back-crossing and judicious selection attempts are being made to obtain plants combining the desirable characters of the two species.

(b) *Solanum Melongena* (2n = 24) × *S. incanum* (2n = 24).—The F_4 progenies of the cross *S. Melongena* (T. 12) × *S. incanum* and F_2 and F_3 progenies of *S. Melongena* (Muktakeshi) × *S. incanum* were grown and studied for spininess, colour, size and bitterness of fruit and incidence of borer attack. Promising plants have been selected. F_1 and F_2 progenies of other crosses, like *S. xanthocarpum* × *S. Melongena, S. xanthocarpum* × *S. indicum* were also studied.

(c) *Lycopersicon esculentum* (2n = 24) × *L. pimpinellifolium* (2n = 24) — Further selections were made in the several back-cross progenies of this cross and forms with good fruit size, and yield and early maturity were selected. The species *L. hirsutum* and *L. peruvianum* were also grown and studied. Attempts were made to cross them with the other two species.

(iii) *Other genetical investigations, Gram.*—Further studies on the narrow leaf mutation in gram have shown that the gene *nlv* is responsible for the expression of the mutant characters, viz., narrow-leaf, narrow-standard and keel and slit ovary.

Chilli.—A bunch mutation like the one observed previously in I.P. 46A was found to occur in I.P. 34; the mutant character was again found to be due to a pair of recessive genes.

Pigeon Pea.—Observations on the F_2 generation of the cross (Cawnpore mutant × normal) gave a segregation of 15 normal : 1 mutant. It appears that the abnormal flowers and the obcordate leaf characters of the mutant were inherited together as if controled by a single gene. Further studies are in progress.

In spite its having apparently normal pollen, the sterile mutant mentioned in the last report failed to set seed when used as the pollen parent in crosses with several normal types. The mutant character is being maintained for further studies through heterozygous normals.

A case of sepaloidy which appears to be the result of gene mutation was observed in the variety C.P. 3. It gave a monofactorial segregation in F_2, the mutant character being recessive to the normal.

Safflower.—Fertile plants with twisted branches were observed at Pusa in certain cultures. The nature of this abnormality is being investigated. The sterile mutant with twisted non-branched stem is being maintained through heterozygous normal plants.

Inheritance of sex in Luffa.—F_2 generation of the cross *L. acutangula* (hermaphrodite with clustered fruit) × *L. acutangula* (monoecious with solitary fruit) was grown and studied. The F_1 plants were monoecious with solitary fruit. In the F_2 the following ratio was obtained: 9 monoecious, solitary fruited: 3 hermaphrodite, cluster fruited: 3 female, cluster fruited: 1 hermaphrodite and male, solitary fruited. Representative plants were selfed and suitable backcrosses made for further study.

5. *Physiological Investigations.*

(i) *Drought resistance studies with wheat.*—These studies were continued using seven species of wheat. The treatment giving desiccation at the anthesis stage was omitted as previous experience showed that all varieties suffered very severely from drought at this stage, there being no varietal differences. Pretreated and untreated control seeds were grown in the same box with a view to eliminating errors in comparison. The following conclusions could be drawn —(i) All the species of wheat under study were not adversely affected by drought at the tiller initiation stage. The wilted plants revived from the effect of drought remarkably well and gave as good a growth and yield as the fully watered plants and in some cases gave even a better performance than the latter. These results confirm the findings of the previous year. (ii) Wilting at the shooting stage, on the other hand, reduced growth and yield of the different species to varying degrees; the later the flowering the greater was the damage due to drought, so much so that in the very late *Triticum monococcum* even earing was considerably retarded and practically no grain was formed. (iii) Plants from pretreated seeds recovered from drought much more quickly than those from untreated ones. (iv) Correlation between drought and phasic development was observed.

(ii) *Photoperiodism and vernalization.*—A complex experiment involving two temperature treatments, three light treatments and twelve varieties belonging to nine different species of wheat (which included the seven species used for the drought experiment) was carried out in 576 pots. All growth observations as well as the harvest data have been collected. Although the full analysis of these is not yet available, the general trends of the results indicate that: (i) the light and heat requirements for growth and development of different species of wheat are different; (ii) the greater the amount of light given in a certain period the greater is the acceleration in development; (iii) temperature and light effects are inter-related; (iv) alteration in the rate of the developmental process as a result of differential light and heat treatments change the whole growth symmetry of the plant. The change, however, is in

different phases and components of growth and not so much in its total magnitude; (v) very late flowering species (winter varieties), which generally give very shrivelled seeds at Delhi on account of their grain-filling and ripening processes taking place in the months of April and May, produced well filled plump grains as a result of a shift in their time of flowering from April to February under long day conditions and vernalization of their seed. This was probably due to the lower temperature and higher humidity during their ripening period.

With the co-operation of Mr. Boshi Sen of Almora 63 Indian wheats which (out of the 150 varieties tried) had responded to vernalization treatment during the previous year were vernalised and sown in replicated plots along with untreated controls simultaneously at Delhi and Almora. Sixty-two of them showed a response to vernalization; they flowered from less than one week to two weeks or over earlier than the controls. Only one variety was indifferent to the treatment.

An experiment was conducted to compare the performance of vernalized and unvernalized control seeds of gram type I.P. 9 when sown on different dates in the season. Five sowings were made at fortnightly intervals from 11th October 1944 to 6th December 1944. The vernalized plants showed distinct earliness in flowering as compared to the controls in all the five sowings; the degree of earliness ranging between three weeks in the first sowing to one week in the last.

6. *Miscellaneous Studies.*

(i) *Study of hybrid vigour and the possibility of its exploitation in agriculture.*

Brinjal.—Five inbred lines and nine F_1 hybrids, including 3 pairs of reciprocal crosses were under study. Evidence of hybrid vigour in respect of yield and certain vegetative characters was obtained. Reciprocal crosses differing in seed size were equal in producing hybrid vigour. Cuttings of reciprocal hybrids and parents were made and rooted with a view to studying the maintenance of hybrid vigour through vegetative propagation. Their percentage establishment was as high as 80%. This study is under way.

Seed of the hybrid "Pusa Purple" was distributed for trial in the Provinces. Reports so far received indicate that the hybrid has done well in Madras, Bengal and the United Provinces.

Maize.—Inbreeding and experiments on hybrid vigour were continued. A number of varieties received from Africa, Canada and Australia were added to the collection.

(ii) *Seed-Setting in Berseem.*—Five varieties of berseem were grown for seed-setting studies at Delhi and Pusa as in the previous years. The data obtained at both the places during 1939-1945 have been analysed and the conclusions found to be in conformity with those already reported. The role of pollinating bees for effective fertilization has been studied in detail and their importance in seed-setting established.

(iii) *Cryptostegia investigations.*—Experiments were undertaken to determine the best method, the best age of plant and the best time of the year for pruning plants to promote the maximum growth

possible were in progress. This method of obtaining rubber was less laborious and more economic than tapping of latex and could give a yield of about 90—110 lbs. rubber per acre per year at a comparatively lower cost. The experiments have been concluded and a detailed report on these investigations is being submitted separately.

II. CROP OUTTURNS AND SEED DISTRIBUTION

The season was very favourable to crops and yields much higher than the average were obtained in wheat, oats, gram and other crops. The quality of produce was also very good. The *Solanaceous* crops, viz., tobacco, chilli, brinjal and tomato and pigeon-pea were considerably damaged by frost. The incidence of rust in wheats was moderate but that in linseeds was exceptionally heavy. Seeds of improved strains were supplied by the Section and the Botanical Sub-station, Pusa to the Departments of Agriculture of the various Provinces and States and also to private growers.

III. ADVISORY

As in previous years, a large number of enquiries was received from all over the country and from abroad regarding varieties of crops, methods of breeding and cultivation, economic wild plants, tobacco curing, etc., and the information asked for was supplied.

A number of plant specimens were identified for various correspondents. A number of scientific articles were also referred for the Imperial Council of Agricultural Research.

IV. PROGRAMME OF WORK FOR 1945-46 and 1946-47

1. The wheat investigations described in this report will be continued.
2. The breeding of disease-resistant potatoes, wilt-resistant pigeon-peas, rust-resistant linseed, and of both Virginia and rustica tobaccos will be continued.
3. The cytogenetical studies of *Brassicae* will be continued.
4. The studies bearing on fundamental cytogenetic research including polyploidy and mutations will be continued.
5. The work on the collection, study and utilization of wild relatives of crop plants will be expanded.
6. The physiological studies on drought-resistance and vernalization of Indian crop plants will be continued.
7. The studies on hybrid vigour particularly the genetical aspects in maize and seed-setting in berseem will be continued.
8. The collection, registration and maintenance of crop collections will be continued.

REPORT OF THE SUGARCANE EXPERT, COIMBATORE,

(Nand Lall Dutt)

I. INTRODUCTION

This report deals with the work conducted at the Coimbatore Sugarcane Breeding Station as also at two of the Schemes connected with the Station, viz., (1) Sugarcane Sub-Station, Karnal, and (2) Scheme for Research on Sugarcane Physiology, Coimbatore. These two Schemes are financed by the Imperial Council of Agricultural Research. The work on Cyto-genetics is being conducted by the Second Cane Breeding Officer.

II. SUGARCANE BREEDING

(a) Hybridization and Selection

The season was quite favourable for flowering and most of the crosses as programmed were effected. As in previous years, the crosses were divided into Bulk, Semi-bulk and Experimental according to the number of seedlings to be raised in each. In the six bulk-scale crosses, four were with Co. 301 as pollen parent on Co. 349, P.O.J. 2878, Co. 421 and P. 4785. The other two were Co. 464 × Co. 440 and P. 4785 × Co. 453. In the semi-bulk crosses Co. 508 has figured both as a male and female parent. In the experimental crosses, the parent which deserves mention is G. 1051—a seedling of the Burma form of S. spontaneum. It has excellent vigour and habit of growth. From the Physiologist's plots two arrows of Burma spontaneum (a variety which does not usually arrow at Coimbatore) were available and were utilised for crossing with P. 4626 and Co. 545.

In the Sorghum crosses, the older Sorghum seedlings Co. 351, Co. 356 and Co. 357 were again pressed into service and crossed with Co. 545. The opportunity was also taken of utilizing certain sweet sorghums which have quite good sucrose content. Eight such varieties (one of them with 13% sucrose in the stalks) were obtained from the Millets Specialist, Coimbatore and used as pollen parents on P.O.J. 2725, P.O.J. 213, Co. 349 and Vellai.

In the Bamboo crosses, four combinations were effected, viz., B.h. IX × P.O.J. 2878, B.h. IX-57 × Co. 508, B.h, V × P, 4626 and B,h, V-24 × Co, 508,

In all, nearly 250 crosses were effected, and over 100,000 seedlings were transferred to the First Ground Nursery. The number of seedlings transferred was a little less as compared to the previous years on account of heavy rains which affected seed germinations. The number of seedlings transplanted for the full year test i.e., in the Second Ground Nursery was nearly 20,000. About 650 promising seedlings were selected for the One-row test. The number of seedlings in the Six-row trials was about 200. In the Final selection, eleven seedlings were raised to the status of Co. canes. Their parentages and general characteristics are given elsewhere in the Report.

(b) STUDY OF SPECIAL CHARACTERISTICS

(i) *Early and Late ripening canes*

For obtaining seedlings which mature early, the parents so far employed at the Station are P.O.J. 2725, Co. 349 and Co. 508. During the year under

report, the seedling canes in the preliminary trial were analysed and those of the following combinations were found to be early in maturity:—(1) Co. 349 × Co. 453, (2) Co. 421 × G. 2291 (Co. 349 × Bamboo), and (3) P.O.J 2878 × Co. 301.

For obtaining seedlings which mature late, the parent for the thicker class of canes has been Co. 443. For the medium type, the parent for obtaining late maturing canes which has been employed very recently is Uba Marrot. The variety P.O.J. 2961 also gives late maturing seedlings. During the year under report the seedling canes in the One-row trial from the following combinations were found to be late in maturity:—(1) Co. 213 × Co. 313, (2) Co. 349 × G. 3287 (Co. 349 × Uba Marrot), and (3) Co. 508 × P.O.J. 2961.

(ii) *Pithy and Non-pithy canes*

The following nine crosses were examined for obtaining indications about the inheritance of pith. One hundred seedlings were examined in each cross and the percentage indicated against each represents the seedlings which showed pith prominently:—

(1)	Co. 213 × Co. 301	36%
(2)	P.O.J. 2878 × Co. 301	40%.
(3)	Co. 527 × Co. 508	48%.
(4)	Co. 213 × Co. 313	66%.
(5)	Co. 281 × P.O.J. 2961	66%.
(6)	Co. 349 × Co. 605	75%.
(7)	Co. 349 × Co. 453	75%.
(8)	Co. 385 × Co. 545	78%.
(9)	Co. 508 × Uba Marrot	82%.

From the above it will be seen that Co. 301 as pollen parent has a tendency to transmit solidity of core to its progeny. It has done so even when crossed with a highly pithy cane like P.O.J. 2878.

(iii) *Fodder canes*

As is well known even the ordinary commercial canes are, in times of scarcity of fodder, pressed into service and cut up for feeding to cattle. Such instances are Katha in the Punjab and Uba and Co. 290 in Australia. The Coimbatore Station has, however, already evolved three special seedlings (Co. 559, Co. 560 and Co. 561) intended for fodder. These are back crosses of sugarcane × S. halepense with S. halepense and their general characteristics are more on the Sorghum side.

The progeny of a few combinations of Saccharum have been examined during the year with a view to selecting fodder canes. The criteria for this selection have been (1) softness of leaf, (2) profuse tillering and (3) capacity to give a cutting once in every three months or so.

(iv) *Chewing canes*

About half a dozen seedling canes have been under observation. The best that can be done at present in the matter of varieties for chewing is to take

E.K. 28 and B. 6308 as standards since they are already under cultivation in certain tracts for this purpose.

(v) *Salt resistant canes*

Facilities exist at the Station for testing canes against salinity. Field No. 3 is saline and the water of well No. 2 which is near this field is highly saline. A number of varieties (21 varieties) were planted in a plot in this field and irrigated with water from well No. 2. The varieties G. 1051 (a seedling of Burma spontaneum), Co. 432 and Uba, Marrot have been found to be quite resistant.

(vi) *Drought and Frost resistant canes.*

The chief method to ensure hardiness (including frost resistance) in seedlings that is being employed at the Station is to utilize such parents in breeding as have S. spontaneum blood in them. This method has served very well. But it seems to be important to have some tests at the source itself (i.e., Coimbatore) which might indicate the hardiness or otherwise of the seedlings before their release to the Provincial Stations. The latest view about the key factors in drought and frost resistance is that they are protoplasmic in nature. Though other factors reinforce the protoplasmic ones, they are by themselves ineffective. A beginning is therefore being made to study certain of the protoplasmic qualities, viz., Bound water. sap concentration, coagulation, viscosity, etc.

III. THE GENUS SACCHARUM AND ALLIED GENERA

Watt's Dictionary of Economic Products gives the information on the systematic position of the genus Saccharum and of allied genera as also on the agricultural aspect upto the year 1907. The Council of Scientific and Industrial Research, New Delhi, are bringing out a new compilation 'The Dictionary of Economic Products and Industrial Resources of India' to embody the advancements in pure and applied aspects made during the last half a century. The advances made with regard to the Economic Botany and Agriculture of sugarcane were summed up in the shape of an article and supplied to the Chief Editor of the proposed Dictionary. In the meanwhile a Survey of Sugarcane Research was also conducted on behalf of the Imperial Council of Agricultural Research, New Delhi. In the course of the above Survey, the need for an expedition to collect the various forms of S. spontaneum was emphasized. This arose because of the pioneering work at the Coimbatore Sugarcane Station of utilizing the wild Saccharum in breeding work.

The delimitation of the genus Saccharum from allied genera has undergone changes recently. The present conception of Saccharum favours its being split into three separate genera, viz., (1) Saccharum, Linn., (2) Narenga, Bor, and (3) Sclerostachya, A. Camus, The position as regards Erianthus is that according to some all the species of Erianthus should be transferred to Saccharum while others have reduced several species of Saccharum to Erianthus. But it is felt justifiably that 'the question of the validity of Erianthus as a genus must await further research'. The above position of the genus Saccharum and the allied genera cannot be said to be a lasting one as several features of this group still stand in need of detailed study. India is quite rich in the various forms of Saccharum and allied genera and it is proposed to organise an expedition for assembling these forms for an intensive study as also for assessing their value as breeding material at Coimbatore.

IV. INVESTIGATIONS.

(i) *Cyto-genetical studies.**

From the germinations of some crosses with different officinarum types among themselves it is found that only very few seedlings survived though in some crosses the germination was not poor. On the other hand when crossed with S. spontaneum a good number of viable seedlings were obtained. This behaviour coupled with the fact that the selfing of the officinarums also does not give viable seedlings, indicates that the haploid genom of sugarcane may have unfavourable recessive genes for viability.

Cytological investigations on two sets of back crosses one with (P. O. J. 2725 × Sclerostachya) × Sclerostachya and the second, (S. officinarum (Vellai) × Sclerostachya) × Sclerostachya showed that in the cross (Vellai × Sclerostachya) × Sclerostachya only unreduced gametes functioned. In P. O. J. 2725, on the other hand, there were only two seedlings where unreduced gametes had functioned. The introduction of S. spontaneum in a cross with Vellai × Sclerostachya hyrid (F_1) gave rise to vigorous and uniform seedlings.

Confirmatory genetical and cytological evidence was obtained this year of the fact that Co. 421 in addition to its haploid gametes ($n = 59$) functioning in crosses and selfs, often contributes a chromosome complement of a different number, viz., ($n = 43$).

The anatomical features and their relationship with resistance to red rot disease are being investigated in the inter-generic cross P. O. J. 2725 × Sclerostachya and in the back cross progenies of the same with Sclerostachya.

It was again confirmed this year that though sugarcane pollen remained viable for more than a month as tested in agar-sugar cultures it had lost its fertilizing capacity three days from the date of collection.

(ii) **Physiological studies*

In connection with the studies on the chemical composition of the flowering variety (Co. 421) as compared to the non-flowering variety (Co. 442), the following determinations were made:—Total carbohydrates, sucrose, glucose, total Nitrogen and insoluble Nitrogen portion. The data indicate that the amount of soluble carbohydrate increases with age in both the flowering and non-flowering varieties, but it throughout keeps at a higher level in the flowering variety. The ratio of soluble carbohydrate to total carbohydrates also remains higher in the flowering varieties. The most significant difference is however seen in the amount of soluble Nitrogen in the stem portion, it remaining low in the non-flowering variety while in the flowering variety it tends to remain high and finally in November when the plants are changing from the vegetative to the reproductive phase the amount of soluable Nitrogen is 3½ times that in Co. 442.

In the photoperiodism experiments, the last year's results with the non-flowering variety S. spontaneum Burma, (which was given prolonged periods

*The work on cytogenetics is conducted by Second Cane Breeding Officer, Dr. N. Parthasarathy.

**This scheme is financed by the Imperial Council of Agricultural Research, and the work is conducted by the Plant Physiologist, Mr. N. D. Yusuf.

of darkness, i.e., only 2 hours of day-light daily, to its potted top portions) were confirmed. This year a number of healthy and normal arrows became available as a result of the above treatment and were used for crossing. The varieties P.O.J. 2725, Co. 421, and P.4626 were subjected to 9, 10½, normal (12), 13½, and 15 hours day-lengths from 1½ month after planting to the 7th month. The flowering of P.O.J. 2725 was delayed by 46 days with 10½ hours day-light. The others flowered only in the control (i.e. 12 hours).

In the manurial and irrigation treatments the non-flowering variety Co. 468 flowered profusely when given only an initial dose of manure and twice the usual number of irrigations.

In the pot experiments the last year's results have been confirmed regarding Baroukha 13 A and Sewari which flowered in the no manure and one dose manure series.

(iii) *Seed Germination studies.*

The seeds of Co. 419 and P.O.J. 2878 have been stored under three different conditions, viz., (1) in sealed tins in an atmosphere of CO_2, (2) sealed tins without CO_2 and (3) in paper packets; with a view to study their viability and the changes brought about in chemical and enzymatic characteristics.

The seeds of Co. 419 were taken up for a qualitative determination of the enzymes. Diastase and Invertase were found to be quite prominent. Trypsin was noticed only in traces.

(iv) *Chemical Studies.*

Though a few determinations of such chemical constituents in the juice as albuminoids, amino compounds, colloids, mineral matter, P_2O_5, etc., (which profoundly influence the manufacturing quality of varieties) have been made at the Station off and on, no systematic data are available on this very important aspect. It is proposed to pay greater attention to these characters before releasing the seedling-canes from Coimbatore and a beginning is being made in regard to the above determinations for the more important parent varieties as also the varieties already in cultivation.

V. *SUGARCANE SUB-STATION, KARNAL.

The Superintendent of the Sub-Station deserves credit for maintaining the Live Herbarium efficiently and for recording the botanical descriptions of the different varieties including line drawings of the various parts of the cane plant in the varieties in cultivation in the various tracts. Notes on germination, tillering and stand have also been recorded as an additional help in the correct identification of varieties. The Superintendent should be able to visit the Provincial Stations in the North Indian cane tracts for rendering help in identification work. The Indian Central Sugarcane Committee rightly laid stress on this at their last meeting when considering the work of the Sub-Station. The paucity of staff at the Sub-Station is a handicap in this direction.

The study on the flowering of the wild Saccharums, particularly *S. spontaneum,* has revealed that (i) there are some which flower both at Karnal and at Coimbatore, (ii) certain sub-tropical types flower earlier at Coimbatore by about a month as compared to Karnal, (iii) certain tropical varieties also

*The Sugarcane Sub-station is financed by the Imperial Council of Agricultural Research.

flower earlier at Coimbatore than at Karnal, (iv) certain tropical varieties flower only at Coimbatore and (v) certain sub-tropical varieties flower only at Karnal.

VI. DISTRIBUTIONS FROM THE COIMBATORE STATION

1. As canes

About 60 sugarcane parcels to twenty one different Testing Stations in India were despatched during the year.

Under orders from the Government of India, cuttings of five Co. varieties were despatched to Mr. Ahmet Yolac, Member, Turkish Sugar Monopolies, Ankara, Turkey.

Under instructions from the Government of India, External Affairs Department, five Co. varieties and one Barbados variety were despatched to Col. E. W. C. Noel, C.I.E., D.S.O., Iran.

As desired by the Director of Commercial Intelligence, about 100 one-foot pieces of 5 different types of sugarcane preserved in formalin-copper acetate solution were supplied to the Imperial Institute, London, for educational purposes.

2. As seeds

The fluff of the crosses Co. 385 × Co. 312, Co. 421 × Co. 508 and Co. 527 × Co. 312 was sent to the Sugarcane Research Station, Shahjahanpur. The Sugarcane Specialist, Punjab, was supplied with the fluff of Co. 312 G.C. and Co. 313 G.C.

VII. NEW COIMBATORE SEEDLINGS

The parentages and general characteristics of Co. seedlings distributed to the various Provincial Testing Stations during the year are given below:—

Co. No. — *Parentage and general characteristics*

Co.623—Co. 449 G.C. (Likely father Co. 450). Uniform medium-thick canes. Vigorous grower and good tillerer. Practically non-flowering. Mid. season in ripening.

Co.624—Co. 419 × Co. 453. A cane of good habit and satisfactory sucrose. Fair in yield and mid-season in ripening.

Co.625—Co. 443 × Co. 281. A thick cane of fair vigour and quite good habit. Somewhat late in ripening.

Co.626—Co. 464 × Co. 313. Quite a promising cane. Should be watched Combines good yield with early maturity and satisfactory sucrose.

Co.627—(Co. 421 × Co. 440) × (Co. 419 × Co. 440). A high sucrose early cane of moderate yield.

Co.628—Co. 603 × (Co. 459 × P.O.J. 2878). A thickish cane of early maturity and satisfactory juice quality.

Co.629—P.O.J. 2878 × Co. 313. An early ripening cane of moderate yield.

Co.630—P.O.J. 2878 × *Sorghum Durra*. An early ripening cane of satisfactory yield.

Parentages and general characteristics (continued).

Co. No. — *Parentage and general characteristics*

Co.631—Co. 349 × Co. 313, A late ripening cane, practically non-flowering. Leaf-sheaths highly spiny but strip easily.

Co.632—Co. 508 × (P.O.J. 2878 × S.G. 63|32). A mid-season cane of fairly heavy yield. Sparse flowerer,

Co.633—(Co. 349 × (*Vellai* × *S. robustum*)) × Co. 419. A mid-season cane, practically non-flowering and non-pithy. Fairly vigorous in growth.

VIII. PROGRAMME OF WORK FOR 1945-46

Breeding with particular emphasis on specialised characters as 'early' and 'late' maturity, disease resistance, non-pithy character of the stem and chewing quality. Attention will also be paid to evolving Fodder Canes.

Cytogenetical studies with a view to investigating the mode of inheritance of characters in *Saccharum* and allied genera.

Physiological studies on the chemical composition of flowering and non-flowering cane varieties and the initiation of reproductive phase in non-flowering canes by photo period treatments and chemicals.

Seed germination studies with particular reference to viability and the changes brought about regarding chemical and enzymatic characteristics.

The relationship of anatomical and other characters to disease drought and frost resistance and their inheritance in cane hybrids.

Determination of albuminoids, collaoids, etc., in the seedling canes before they are released from Coimbatore.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(Dr. S. V. Desai, Second Agri. Chemist)

I. INTRODUCTION

The difficulties to obtain essential supplies continued and investigations of minor importance and analysing of samples of routine nature had to be curtailed to meet the situation. Data of some experiments carried out in previous years were written up for publication.

II. SOIL STUDIES

1. *Soil maps.*—Soil maps showing districtwise distribution of nitrogen, phosphoric acid and potash were prepared from the available data. Data for the available P_2O_5 and potash were also collected but for most of the districts they were not enough for indicating the normal distribution hence they were not mapped. A tabular statement showing these figures was prepared. In this the numbers of analytical data available as well as maximum and minimum amounts for each nutrient in the district are given.

2. *Comparative soil studies.*—(i) The work under this head was confined to writing up the results of analytical work carried out during the last few years. A few of the papers have already come out.

(ii) *Absorption and retention of ammonia by Indian soils.*—For measuring the absorption of ammonia a new procedure was followed. It was different from other methods in the sense that as far as possible field conditions were imitated. 200 gms. of soil were put in a soil percolator with the requisite amount of ammonium sulphate and moistened with water, equivalent to its water holding capacity. The whole system was allowed to attain equilibrium for 24 hours after which it was leached with 500 cc. of water. Ammonia was determined in the leachate and the amount of the ammonia retained by the leached soil was estimated in the second leachate obtained by leaching it again with 500 cc. of N NaCl solution.

Preliminary experiments showed that upto a certain limit soils absorbed added ammonia completely but with higher doses, ammonia came out in the leachate. To find out the maximum amount of ammonia which the soil could absorb, absorption at different levels before and after the appearance of ammonia in the first leachate were plotted on a graph against the amount applied. Straight line joining the points before ammonia appeared in the leachate and a straight line joining the points after the appearance of ammonia in the leachate were produced to meet and the point of intersection indicated the maximum amount that could be retained by the soil. A number of soils were studied by this method. The results would be presented later when correlation with other soil properties and composition is worked out.

3. *The trace elements*—(i) *The distribution and factors affecting the availability of trace elements.*—The soil analysis for trace elements did not indicate the amount of trace elements that were available in the soil for the crop. The proportion per cent of the minor elements in the finer fractions of the soil namely clay to the total content was considered to be a measure for available amount. With this view a number of soils and their clays were analysed for boron and manganese. Low boron ratio per cent was found in Lyallpur and Surat soils, and a low manganese ratio per cent in Karachi.

Coimbatore, Karimgunj, Padegaon and Sylhet soils. It would be of interest to see how the crops in these soils respond to an application of trace elements, boron and manganese, respectively.

(ii) *Trace element distribution in soil having good and bad patches of growth.*—A study of the soil of the good and bad patches of growth, in wheat plots at Delhi showed a low ratio per cent of clay boron to total soil boron of an order of 6 per cent and less. The ratio per cent of manganese distribution was also similar. It was observed that these soils contained a large proportion of K and the uptake of minor elements was adversely affected by this excess. The effect of minor elements after counteracting this excess by an application of lime is proposed to be studied.

(iii) *The effect of trace elements in Delhi and Guntur soils.*—This was investigated by using tobacco as the test plant in the pot culture experiments. In Guntur soil the addition of boron and manganese was beneficial only when large amount of nitrogen was applied to the soil. The yield was highest when nitrogen was supplemented with these trace elements. In Delhi soil the addition of boron and manganese was beneficial only when nitrogen and phosphorus were applied together to the soil. Here too the maximum yields were obtained by this treatment. It would be thus seen that deficiency in minor elements was brought to the fore-ground when the soil was manured with deficient major elements and when the yields reached a high pitch.

(iv) *Physiological diseases and minor elements.*—In investigating the disorders caused by deficiency of minor elements it was noticed that the deficiency of minor elements resulted in an excess intake of some other element. In the Bombay Presidency, Mr. N. V. Joshi while investigating the betelnut disease found that the deficiency in zinc was associated with excess intake of manganese. In Assam deficiency of managanese in citrus was associated with excess intake of iron. In Delhi soil in barley and wheat the deficiency of boron and manganese was associated with excess absorption of potassium. Pot culture experiments with tobacco also showed that the deficiency of boron was associated with the excess intake of potassium.

4. *The study of the formation of alkalinity in soils.*—(i) *Pusa soil.*—Examination of alkaline patches in Pusa soil which is highly calcareous showed that there were three types of alkaline formations—(a) soil with high concentration of soluble salts chiefly sodium sulphate and calcium salts, (b) soils with high concentration of soluble salts chiefly sodium sulphate, carbonate and bicarbonate with absence of soluble calcium salts, and (c) soils with low amount of soluble salts, the soil complex being sodiumized due to small amounts of clay and high amounts of $CaCO_3$. The alkaline patches were fugitive in nature. They disappeared in monsoon period and reappeared in winter. The pH values were always high with full or partial sodiumization of the soil complex. The crop growing on the spots contained high amounts of sodium in the ash.

(ii) *Karnal soil.*—The effect of artificial mulch on the movement of salts in usar soil at Karnal was studied. Eight plots were laid out, four of which were covered with mulch consisting of farm wastes. Samples were taken from the surface soil at regular intervals to study the accumulation of salt on the surface. This showed that at the start the total amounts of salts were the same in mulched and unmulched plots. Later on during hot weather there was rise in both the plots but the increase in the unmulched plots was greater than that in

mulched plots. In rains there was a great decrease in salt concentration and the decrease in unmulched plots was much greater than in mulched plots. During winter again there was rise in both the cases, the rise in mulched plot being very much less than in the unmulched ones. The movements in both the series were parallel except during rains when the salt concentration in the unmulched plots decreased to a greater extent than in the mulched plots. This showed that mulch was efficient in controlling the movement of salts during hot weather but during the rains, it hindered the rain water from washing down the salts from the surface layers. The proper course for the control of the movement of salts was to provide mulch in the hot months and remove it during the rains.

5. *Soil Survey.*—The work was carried out under the Soil Survey Scheme financed by the Imperial Council of Agricultural Research. The collection of soil data from different parts of India has been completed. The information about soil types has been recorded from four points of view, viz., geological, land assessment, fertility and textural survey of surface samples, and genetical study. Collation of existing information and soil data suggest that soils of India may be divided into the following eight types—(a) red soils, (b) laterite and lateritic soils, (c) black soils, (d) alluvial soils, viz., (i) coarse alluvium, (ii) fine alluvium, and (iii) deltaic alluvium, (e) desert soils, (f) forest soils including plantation soils, (g) saline and alkaline soils praticularly with reference to free salts, and (h) peaty and marshy soils. These soil types (a to h) have been dealt with fully in separate sections. The following data have been collected an collated, wherever they exist with respect to each of the above soil types—soil analysis; profile studies; the minerological, biochemical and colloidal research; crops grown and area and yield per acre; rotations practised; irrigation; comparison between dry and irrigated methods of agriculture; irrigation projects; cultivation operation; dry farming; manurial data with N, P and K; erosion and soil conservation practices; soil reclamation and land assessment data in relation to crops. Wherever data and information permit, a preliminary soil map of each of the Provinces and States has been given.

III. AGROCHEMICAL STUDIES

1. *Relative values of nitrogen in F.Y.M., composts, oilcakes, sulphate of ammonia, green manure and activated sludge.*—Due to timely rains the growth of wheat was so heavy in the manured plots that the crop was badly lodged and the yields were adversely affected. The plots showing the best growth showed the worst lodging. The growth measurements and other agronomic data were in direct relationship with the availability of the nitrogenous manures. The availability of nitrogen in the manures was measured by estimating their nitrifiability. The field experiments as conducted had a fallow wheat rotation and the effect of fallowing in making the nitrogen of the soil available had to be taken into consideration. This was the reason why the margin of difference between the no manure and manured plots was narrow. The order of availability of manures in Delhi was ammon. sulph., castor cake, mustard cake, green manures of cowpeas and sunn-hemp, activated sludge, compost and F.Y.M. and if the crops had not lodged the yields would have followed the same trend as shown by agronomic observations about the growth. The recoveries of nitrogen by the crop and the nitrogen status of various plots were under study.

(ii) *Relative values of various nitrogenous manures and their recoveries (Old Russell plots).*—In these experiments the yields of wheat followed the same trend as in the previous experiments. The recoveries of the nitrogen from the soil were low. The highest recoveries were from the plots receiving organic manures associated with ammon. sulph. In these experiments rape cake was found superior to all other organic manures and the descending order was similar to the descending order of their nitrogen percentage. The detailed results are given in the report of the Development Scheme.

2. *Study of the after effect of maize crop and its amelioration.*—The pot culture experiments revealed that maize roots excreted toxins which had depressing effect on the microbiological activity of all groups of soil organisms except nitrogen fixers. It was further brought out that these toxins were soluble in water. It was therefore proposed to utilize this characteristic to overcome its depressing effect by flooding the plots after the harvest of maize. The yields of wheat from flooded and unflooded plots did not show significant differences because soon after the harvest of maize a heavy downpour of rain equalized the differences in treatment of the plots. In other series the effect of ammonium nitrate was found to counteract the depressing effect. As the toxins were prone to oxidation treatment, an oxidizing type of manure would overcome this phenomenon. Further an application of nitrate supplied available nitrogen in the early period of the growth of wheat and the adverse effect of toxins which was due to lack of available nitrogen supply in the soil in early stages was overcome.

3. *Legume inoculation.*—At the suggestion of the Imperial Council of Agricultural Research preliminary experiments to study the effect of inoculating the indigenous legumes with appropriate bacteria were started. In an experiment in the sectional area cowpeas were grown. The effect of bacteriophage was also studied side by side. The inoculation with an active culture increased the yields by 8 per cent. The addition of bacteriophage with the culture depressed the yields.

Similar experiments carried out in farm area with three varieties of cowpeas, soyabean, mung, urid, moth, guar and sunn-hemp gave similar indications. The preliminary experiments were carried out on observation plots. So these experiments only indicate the possibilities of increasing the yield of indigenous legume by inoculation with active cultures. New experiments with proper replication for calculating the statistical significance have been laid out this year.

The appearance of bacteriophage in the root nodules of various leguminous plants grown continuously in the same soil was under study. The investigations to find out the period after which the bacteriophage appeared in the root nodules of legumes, growing year after year in the same soil were continued. It was definitely brought out that after three years of successive growth, the nodules of most of the legumes were affected by bacteriophage.

4. *The effect of applying superphosphate to berseem on the development of fertility in Delhi soil.*—In a long term experiment the Imperial Agriculturist has shown that manuring of berseem with a heavy doze of superphosphate results in increased yields of berseem and of the subsequent wheat crops without any further application of manures. Experiments were undertaken by the Chemical Section to elucidate this phenomena. Firstly, the manurial needs of Delhi soil were determined by measuring the rate of decomposition of soil

organic matter by a method evolved in our laboratory. This indicated that soil required both nitrogen and phosphoric acid. In the light of this observation the soils from the Imperial Agriculturist's berseem manurial experiments in which phosphatic and other manures had been applied were examined for their present status of fertility. Berseem was last manured in 1942-43 season and the plots did not receive any further manurial treatment. The three plots 1-D, 1-E, and 1-F in this experiment in Top Block had three different rotations after the harvest of berseem as shown below—

	Plot	*1943*	*43-44*	*1944*	*44-45*
Top Block	1-D	Cowpea	Wheat	Cowpea	Wheat
„ „	1-E	„	„	Fallow	„
„ „	1-F	Fallow	„	„	„

Samples of soils were taken before the sowing of wheat in 1944-45 season. Evaluating the effect of manuring berseem, it was very clear that the application of phosphatic manures had resulted in pronounced increase in growth of berseem because of the supply of P and N. the elements deficient in Delhi soil. The former was supplied through the application of manure and the latter through the fixation of atmospheric nitrogen by the berseem plant itself. The heavy growth of berseem resulted in enormous fixation of nitrogen and the results based upon the amount of roots left in the soil indicated that soil was enriched by nearly 200 lbs. of nitrogen per acre. The amount of nitrogen fixed was different in differently treated plots depending upon the growth of berseem. The soil therefore after the harvest of berseem contained nitrogen and phosphorus in sufficient amounts to wipe of the soil deficiency. With a fallow following the berseem, the organic residues were sufficiently decomposed to supply available nitrogen and phosphates to the next crop of wheat. In plots where cowpeas were sown the nitrogen was not so readily available to wheat, all the same, the legume did not deplete the soil of its nitrogenous stores but only delayed its conversion into available form. The fallowing after wheat again repeated the whole cycle. The crop of wheat removed about 50 lbs. of nitrogen and about 25 lbs. of P_2O_5. It would therefore be seen that this rotation maintained soil fertility for the period without any further use of manures.

The rate of decomposition of soil humus in the soils obtained from these plots, was correlated with the yields and indicated the different levels of soil productivity except in the case of plots which received only high doses of superphosphate. In these cases the decomposition was low but the rate of low decomposition was not due to lack of necessary nutrient required by soil micro-organisms because additions of N, P and K singly or in combination did not increase or stimulate the rate. This showed that the low rate of decomposition was due to causes other than the deficiency of mineral nutrients. The possible explanation of this kind of results was that the supply of phosphates had resulted in the mineralization of organic residues rich in nitrogen. Almost all the organic residues which were easily decomposable had been mineralised and that the slow rate of decomposition that was observed was due to the highly resistant residues left in the soil. This type of soil behaviour was also observed when organic manures rich in nitrogen were associated with superphosphate. The increased microbiological activity not only made the N and P_2O_5 of the added materials available but it also increased the rate at which the soil nitrogen and soil P_2O_5 became available and raised the general status of soil

fertility. The soil was able to supply not only what was put in but considerable portion of its reserve of N, P and K which were formerly not available. Active soil organisms determined by insertion of slides and fixing the micro-organisms on them in the field indicated that good growth of crop was associated with large number of active organisms. In adjoining plots of poor growth the number of active organisms was very low.

5. *Utilization of ammonium nitrate and its mixtures with T. N. T. from surplus ammunition stores as a fertilizer.*—Pot culture as well as field experiments were conducted with ammonium nitrate and its mixtures with T.N.T. in the sectional area. A basal dressing of phosphate was given to the plots so that the deficiency of phosphate may not limit the growth of plants. In other series besides 40 lbs. of P_2O_5 as superphosphate a basal dressing of F.Y.M. prepared anaerobically was given so as to eliminate deficiencies other than that of P_2O_5. Intensive cropping was taken so that nitrogen recuperation by fallowing may not mask the result of nitrogenous manuring. In the pot culture experiments with a view to find out the interaction of ammonium nitrate with indigenous phosphatic manure ammonium nitrate was tried with bonemeal and rock phosphate.

(i) *Field experiments.*—(a) Twenty five plots were laid out with five treatments and five replications in a Latin square design. The treatments were (1) ammonium nitrate, (2) ammonium nitrate plus 1% T.N.T., (3) ammonium nitrate plus 2% T.N.T., (4) ammonium nitrate plus 3% T.N.T., and (5) control. Maize was grown in kharif and the manures were applied in two doses of 20 lbs. each, 3 weeks and six weeks after sowing. The increase due to manuring was 49% to 67% in different treatments over the control. The increases were statistically significant and no detrimental effect due to the presence of T.N.T. in the mixtures was observed. In rabi season wheat was sown after a basal dressing of 40 lbs. of P_2O_5 as superphosphate. The nitrogenous manures were applied at the rate of 40 lbs. N before sowing in a single dose. The yields of wheat showed that ammonium nitrate and its mixture with T.N.T. increased the yields by 101% to 114%. The increases were statistically significant over the control but the differences between the different manurial treatments were not statistically significant. No detrimental effect due to T.N.T. was noticed. A slight stimulating effect due to T.N.T. was noticed during the period of early growth. These experiments with two crops, maize and wheat, showed that ammonium nitrate was an excellent manure for both maize and wheat and that T.N.T. upto an extent of 3% was not harmful to the crops. The total recoveries of N and P_2O_5 by the wheat crop from the control plot was 23 lbs. of N and 13 lbs. of P_2O_5 while from the ammonium nitrate treated plots, the recoveries were 50 lbs. and 19 lbs. respectively. It would be thus seen that more nitrogen than was applied was recovered by the crop.

(b) Field experiments with basal dressing of 40 lbs. of N as anaerobically prepared F.Y.M. and 40 lbs. of P_2O_5 as superphosphate, were laid out in quadruplicate plots. 20 lbs. N as ammonium nitrate and its T.N.T. mixtures were given as manures. The control yielded 20 mds. of wheat while ammonium nitrate treated plots gave 26 to 31 mds. of wheat per acre showing that a dose of readily available nitrogen in the form of ammonium nitrate increased the yield of wheat even when the soil was manured with F.Y.M. The increases were 30% and 55%.

(ii) *Plot culture experiments.*—These experiments were conducted with ammonium nitrate alone as well as in combination with indigenous phosphates, bonemeal and rock phosphate. The results showed that ammonium nitrate, by itself increased the yields by 89%. When supplemented with bonemeal and rock phosphate the increases in yields were 150% and 136% respectively over no treatment and 93% and 123% over the basal treatments of bonemeal and rock phosphate respectively. The bonemeal and rock phosphate by themselves increased the yields by 30% and 6% respectively. All the increases due to the treatments were statistically significant except that of rock phosphate by itself. The results were also examined in another way to find out what increases were given by phosphatic manures by themselves and when associated with ammonium nitrate. The bonemeal gave 30% increase by itself and 32% increase when associated with ammonium nitrate while rock phosphate gave 6% and 25% under similar treatments. This showed that association of rock phosphate with ammonium nitrate increased its efficiency to a great extent.

6. *Agro-chemical experiments.*—The data regarding these long term agro-chemical experiments started in 1944 are being collected and would be interpreted only when more data become available as the experiments progress.

IV. MICROBIOLOGICAL STUDIES

1. *Relation between microbiological status, soil fertility and the composition of the crops.*—The attempts to correlate the rate of decomposition of the soil organic matter and the crop yields indicated that the decomposition depended on the amount of easily decomposable soil humus, and the results were likely to be misleading when the content of organic matter was unknown and variable. Some difficulties were experienced in the interpretation of the data in the phosphatic manurial experiments of berseem when the direct relationship with decomposition and yields was found to be upset. It was, therefore, proposed to estimate carbon in the soil and express the decomposition as a percentage of the soil carbon. When the data were examind in this way the correlation with soil fertility was very uniform and gave a better relationship with the yields than the rate of decomposition formerly used for the purpose. Attempts were made to obtain a regressive equation for yields based on these values and this field of inquiry proved to be promising.

Examination of a number of samples from the farm area indicated that the soils at Delhi were deficient in phosphorus and available nitrogen. The decomposition of organic manures rich in carbon was very slow but the decomposition of organic manures rich in nitrogen such as oilcake was quite rapid and the rate of decomposition was greatly enhanced if phosphates were also added to the soil. The nitrogen of F.Y.M., compost, and activated sludge took about four to six months for being available, green manures took about 2 to 3 months and rape cake took about a month for the same purpose. These data indicated the soil response to various manures and showed direct correlationship with the results of field experiments which though not laid out for this purpose could be analysed for obtaining the crop response to manures in this soil. Whenever the organic manures mentioned above were applied with inorganic fertilisers the yields increased though the amount of nitrogen applied was the same in both the cases. It was observed that the total nitrogen and phosphorus recovered by the plants from the farmyard manured pots were definitely lower than that from the pots manured with inorganic fertilizers. Even the percentage composition of the crops was similarly lower thereby

showing that the rate of the supply of nutrients was definitely lower with farmyard manure than with fertilizers in Delhi soil.

2. *Study of the methods to assess soil fertility with a view to indicate manurial needs of soil.*—The Azotobacter plaque method for determining mineral deficiency in soil and Mitscherlich's pot culture methods were studied.

The Azotobacter plaque method indicated that Delhi soil was poor in P_2O_5 and required phosphates and not potassium or calcium. This was in conformity with our own observations.

The Mitscherlich's method to estimate the available N, P, and K indicated that Pusa soil contained very large amount of N, P and K in available form. This was not borne out by our knowledge of Pusa soils. This led us to the examination of Mitscherlich's equation for arriving at the amount of available nutrients from the data, and it appeared that probably the constant used in the Mitscherlich's formula was dependent upon the climate, specially the temperature of the place. As the growth is dependent upon the temperature the amount of growth obtained in different places and climates would affect the amount of nutrients taken up by the crop. A modification in the formula to include a temperature factor after further study would be suggested.

3. *Anaerobic fermentation of the cattle dung.*—Experiments were continued to study the production of fuel gas. There was a decided improvement in the rate of fermentation as measured by evolution of the fuel gas. A construction of a large fermentation tank for studying the commercial possibility of the process was proposed. The trials to compare the increase in yields by cowdung and litter kept under different conditions were carried out but due to heavy lodging of the crops where the growth was good the results could not be utilized for statistical analyses but the observation of the growth of crop in the field confirmed previous observations and indicated that manure prepared by anaerobic fermentation was superior to all other types namely F.Y..M. prepared by usual farm method and cowdung applied as such early in the season.

4. *Production of butyl alcohol and acetone by microbiological fermentation.*—The effects of different metals and the conditions which were likely to be encountered in the industrial exploitation of the cultures were studied. Effect of zinc was definitely harmful. Other metals such as iron, copper, tin, aluminium, and lead did not appreciably affect the fermentation adversely. Oxides of these metals, however, had a retarding action and specially lead oxide which is used to connect the pipe joints was found to be highly poisonous. A factory was erected by Messrs. Upper Jumna Sugar Mills Co., Mansurpur, under the aegis of the Supply Department to exploit the process.

V. BIOCHEMICAL STUDIES

1. *Calcium and phosphorus content of milk of Sahiwal cows and in their feeds.*—The percentage of CaO and P_2O_5 and their total contents in day to day milk and the ratio of CaO : P_2O_5 were calculated for large number of cows and graphs were drawn to show how this varied in different cows from the premilk stage. The amounts of these elements taken in the feeds were calculated. It was found that calcium and phosphorus of the feeds were not sufficient to keep the balance positive in cows giving more than 30 lbs. of milk per day. Large number of animals were included in the study.

2. *Quality of Berseem fodder as affected by manuring.*—In a further experiment started by the Imperial Agriculturist at Delhi to study the effects of N, P, NPK, etc. on the quality of berseem, phosphorus and calcium were estimated by the Chemical Section weekly and in the regular cuttings from the plots receiving (i) no manure, (ii) 66 lbs. P_2O_5 as superphosphate, and (iii) 40 lbs. of N, 66 lbs. of P_2O_5 and 40 lbs. K in a mineral form. The average percentage of calcium in the crops on dry basis was (i) 2.45, (ii) 2.7, and (iii) 2.8 respectively. This showed that manured berseem was richer in calcium than the unmanured one. The average percentage of phosphorus on dry basis was (i) 0.34, (ii) 0.58, and (iii) 0.54 respectively. This showed that highest amount of phosphorus was in the phosphate manured crop and the crop manured with N, P and K did not contain as high a percentage of P_2O_5 as crop manured with phosphates alone. The crop of the no manure plot contained little phosphorus as compared to the crop manured with phosphatic manures. The effect of these crops on the growth of rabbits was also studied. Batches of five very young rabbits of approximately same collective weights were segregated and fed with berseem from these manurial plots for a period of ninety days. No other food was given to these rabbits. The percentage increase in weight of the batches was plotted on the graph against time to show the comparative growth due to the feeds. The growth curves are given in the appendix. They showed that the crop manured with phosphates only, stimulated the growth to the greatest extent and the crop raised with N, P and K was not so greatly stimulating, but it was better than the unmanured crop. The crop manured with the phosphate alone proved better than the crop manured with N, P and K because of the higher percentage of P_2O_5 in the phosphate manured crop than in the crop manured with N, P and K. It was noticed from a large number of experiments that application of potash to Delhi soil resulted in depression of growth and the uptake of minor elements, boron and manganese, was also adversely affected. All this showed that application of K had a definite detrimental effect on the quantity as well as on the quality of the crop in Delhi soil. Application of nitrogen to a legume was unnecessary and it did not affect the crop in any way, as the crop was able to fix the required quantity of nitrogen from the atmosphere.

3. *Effect of feeding 'Barawadi grass' (Sorghum helepens Pers).*—Barawadi grass grows wild on the farm lands in the district of Beawar in Ajmer-Merwara. It was found that this was poisonous in the early stages of growth. At the advent of monsoon this grass grew luxuriantly and attracted the cattle and was the cause of mortality among the cattle. The grass was found to contain a fatal dose of hydrocyanic acid in the young stage. At the flowering stage the content of hydrocyanic acid was much reduced, and grass could be fed to the cattle at this stage. The hydrocyanic acid content decreased with maturity. The grass was identified as *Sorghum helepens Pers.*

4. *Locust as food and manure.*—The chemical composition of dead and air dry locusts revealed high contents of protein and oil which were 62% and 18% respectively as result of which the food units of the material were exceptionally high. The dead locusts preserved in salt were used by Arabs as food. Inhabitants of Makran and Sind sometimes used them as food in fresh and dried state. As a manure locusts are rich in N, P and K and decompose easily in the soil.

5. *The changes taking place in tobacco during curing.*—In order to find out the factors which determine the quality of tobacco it was first proposed to

study the chemical changes that occurred during flue curing. Samples were collected at different stages during the curing process and were analysed for various constituents. The dry matter of the tobacco leaves decreased by 15% during the curing. The ammoniacal and amide nitrogen progressively increased during curing. The increase was marked during the later stages. The degradation of proteins into soluble forms was marked at the end of the process. There was a remarkable increase in reducing sugars, in the early stages upto 70 hours of curing and then there was a decrease with increase in sucrose formation till at the end the leaf contained 7% of sucrose. The course of these changes requires to be studied further before definite conclusions could be drawn about their significance. The work was done in collaboration with the staff of the Tobacco Research Scheme.

6. *Rubber Investigations of Cryptostegia gradiflora.*—The rate of the formation of rubber and the yields of latex from plants of various ages were studied. It was found that the rate of the formation of rubber was correlated with the age of the plant and to the total mass of the plant tissues. The yield of latex depended upon the number of tapping shoots developed by the plant. The quality of the latex tapped at different times of the day was studied. It was found that quality of the latex was not influenced by the time of tapping but the quantity of latex decreased with continued tappings. Tapping the grown up plant every alternate day gave the highest amount of yields as compared to tapping every day or once in three days. Therefore, this type of tapping was considered to be the most economical. Regarding the effect of seasons it was found that the yield of latex as well as the dry rubber content were highest during the period, December to March. When the latex was not rich in dry rubber content, the amount of rubber obtained as seals or plugs was high and reverse was the case with increased richness of the latex.

Experiments to separate rubber from twigs and some other plant materials by fermentation did not yield encouraging results. This was specially due to the very low content of rubber in these materials and not due to the inefficiency of the micro-organisms to ret the tissues.

7. *Air foam compound as fire extinguisher.*—A field trial for extinguishing petrol fire was carried out with the materials prepared from *Solanum xanthocarpum*. The foam produced was equal in effect to that of soap compounds but was slightly inferior to that of compounds prepared from animal proteins.

8. *Insecticides.*—*'Marc from opium'* Master General of Ordnance enquired whether 'Marc' obtained from opium after the separation of morphine and codeine could be used as an insecticide. A number of preparations were tested by the Imperial Entomologist and the acetate of the 'Marc' was found to possess insecticidal properties.

(b) *Tobacco.*—Estimation of nicotine in varieties of tobacco before and after maturity was undertaken.

(c) *Sulphur.*—Some practical methods for the extraction of sulphur from its ores have been developed.

VI. ROUTINE AND ADVISORY

The following samples were analysed and reported upon:—

Soils	49
Waters	9
Manures and Fertilizers	30
Feeding stuffs	99
Sugarcane juice	204
Wheat	24
Oilseed cakes	34
Tobacco leaves	32
Tomatoes	3
Insecticides	5
Crude penicillin extract	2
Butter	132
Fruit products	102
Honey	7
Bura	117
Gur	6
Bacterial cultures	6
Bacterial Examination of water	2
Blood slides	18
Urine	1

Of the above samples 320 were received from the Imperial Agriculturist, 98 from the Imperial Economic Botanist, 25 from the Imperial Entomologist, 24 from the Imperial Mycologist, 13 from the Agricultural Officer, Ajmer-Merwara, 364 from the Agricultural Marketing Adviser for control of grading and marketing and the rest from miscellaneous sources.

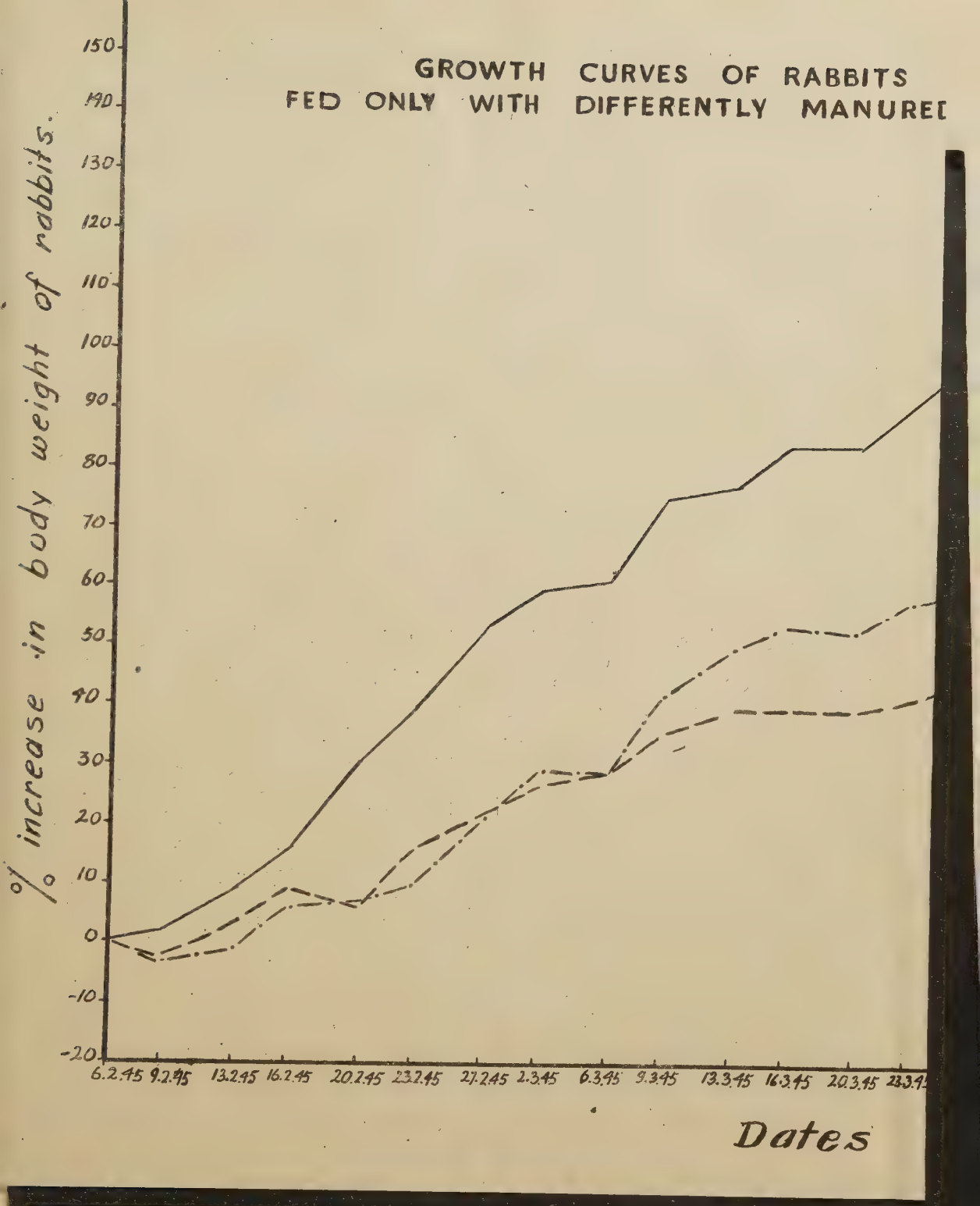
VII. PROGRAMME FOR THE YEAR 1945-46.

Soil Science.—Comparative studies of Indian soils in relation to colour, minor elements and other characteristics would be continued. Study of the formation of alkaline patches in Pusa and Karnal would be carried out.

Agro-chemical studies.—The effect of manures on the development of soil fertility would be studied. The action of minor elements on the physical properties of soil and on the uptake of N, P and K would be investigated. Methods of measuring soil fertility would be compared.

Microbiological studies.—Nutritional requirement of various types of micro-organisms with reference to their effect on soil fertility would be determined. Methods of preparation and storage of manures would be comparatively studied. Inoculation experiment on indigenous legumes would be carried out.

Biochemical studies.—The effect of manuring on the composition of crops and their nutritive quality would be studied. Calcium and phosphate contents of milk would be determined. The extraction and preparation of insecticides from indigenous materials would be carried out.


GROWTH CURVES OF RABBITS
FED ONLY WITH DIFFERENTLY MANURED
% increase in body weight of rabbits.
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
6.2.45
9.2.45
13.2.45
16.2.45
20.2.45
23.2.45
27.2.45
2.3.45
6.3.45
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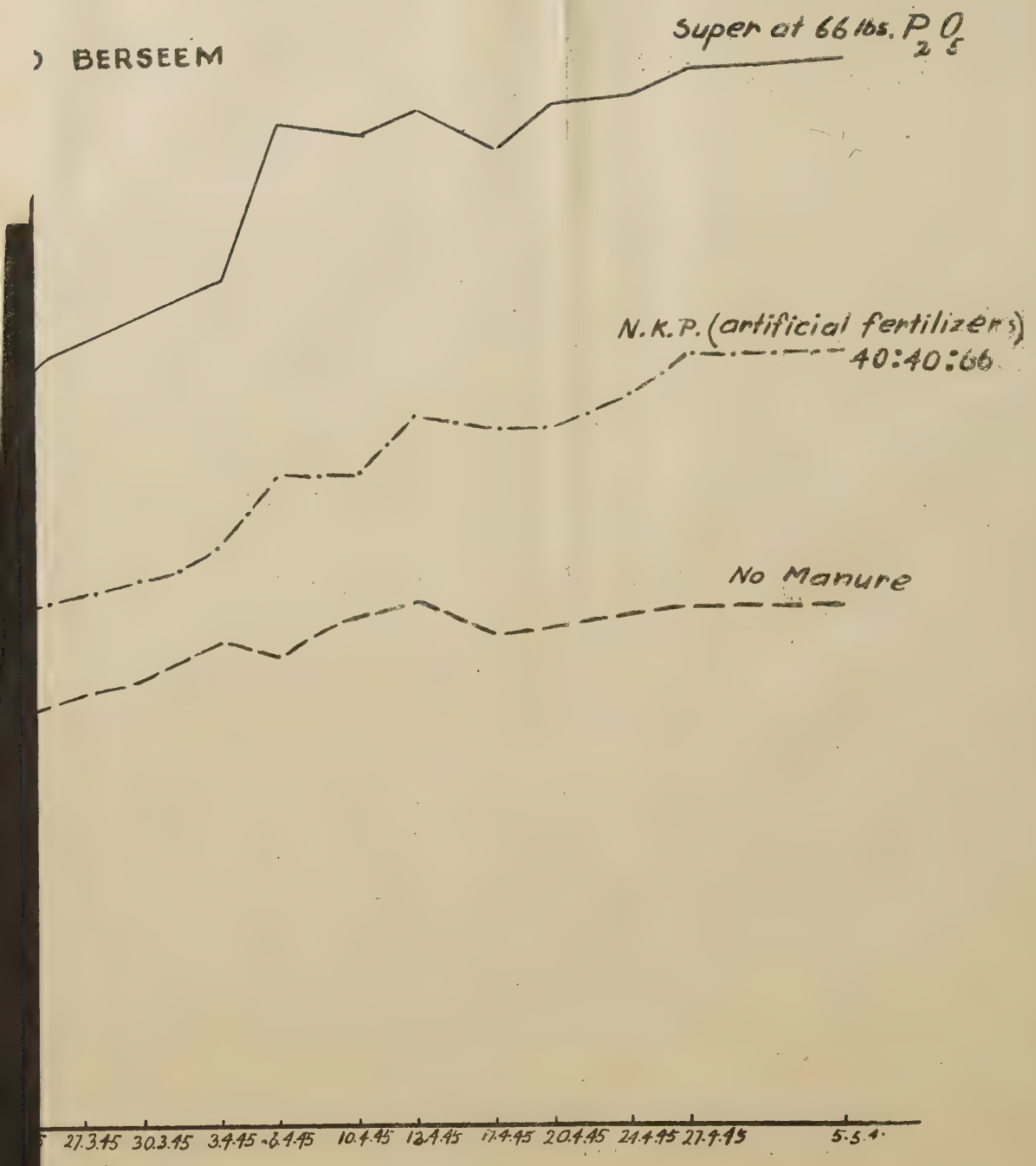
Dates


BERSEEM
Super at 66 lbs. P_2O_5
N.K.P. (artificial fertilizers) 40:40:66
No Manure
27.3.45
30.3.45
3.4.45
6.4.45
10.4.45
12.4.45
17.4.45
20.4.45
24.4.45
27.4.45
5.5.4

Methods of analysis.—Standardisation of some of the methods of analyses and their comparative studies would be undertaken.

Routine and Advisory.—Help to various sections and to outside agencies by analysing different samples specially for research purposes would be given.

PROGRAMME FOR THE YEAR 1946-47

1. *Agro-chemical studies.*—The effect of manure on the development of soil fertility; comparison of the methods of soil fertility.

2. *Soil Science.*—Study of clay forming and rock forming minerals; study of the formation of alkaline patches in Pusa and Karnal.

3. *Soil Survey.*—Survey of Indian soils from modern agronomic point of view.

4. *Microbiological studies.*—Nutritional requirement of various types of micro-organisms with reference to their effect on soil fertility; comparative studies on the preparation and storage of manure; inoculation experiments on indigenous legumes. Methods of determining mineral deficiencies in soil.

5. *Micro-nutrient elements.*—Studies on micro-nutrient elements.

6. *Biochemical studies.*—The effect of manuring on the composition of crops and their nutritive quality; calcium and phosphate contents of milk; the extraction and preparation of insecticides from indigenous materials.

7. *Method of analysis.*—Standardisation of some of the methods of analysis and their comparative studies.

8. *Routine and Advisory.*—Help to various Divisions and to outside agencies by analysis of different samples specially for research purposes.

REPORT OF THE IMPERIAL MYCOLOGIST

(J. F. Dastur).

I. DISEASES OF PLANTS

i. Wheat (*Triticum vulgare Host*).

1. Loose smut, *Ustilago tritici* (Pers.) Rostrup.—Experiments to find out the varieties of wheat which are resistant to this smut were in progress and several varieties were tested during the year. Seventy four varieties were tested against the Pusa collection of the smut. Of these 35 did not take infection and nine were only slightly attacked. The same 74 varieties and eight more, or in all 82 varieties, were tested against the Punjab collection of the smut. In this case 39 did not take infection and 26 were only slightly attacked. Twenty one varieties sent by the Cerealist, Punjab, seven by the Wheat Breeder in Sind and 11 by the Wheat Specialist in C.P. were also tested, the former two against the Punjab collection of the smut and the last against a collection of smut made at Hoshangabad. Nine Punjab varieties and one Sind variety did not take infection while four Punjab varieties, two Sind varieties and four C.P. varieties were only slightly attacked. All other varieties were highly susceptible.

2. Physiologic races of loose smut.—This work which is in progress since 1941 has not given consistent results. As Canadian differentials do not ear well under our conditions, a set of Indian wheats was selected to serve this purpose and investigations, with eight collections of smuts using these differentials, have indicated that there may be two races of loose smut. The same collections were sent to Dr. W. F. Hanna of the Rust Research Laboratory, Winnipeg, Canada, with a request that he determines the number of races that may be present in them using Canadian differentials. Dr. J. H. Craigie writing for Dr. Hanna who is now in the Canadian Army, wrote to say that preliminary work had shown that there may be only one race in those collections; in other words, they all belonged to the same race. A more detailed investigation has been promised and results are awaited with interest.

3. Karnal Bunt, *Neovossia indica* (Mitra) Mundkur.—Observations taken this year at Karnal and at Delhi have shown that the incidence of this disease is very slight. Previous finding that the bunt is air-borne has been further confirmed by experimentation.

4. Flag smut, *Urocystis tritici* Koernicke.—This smut was not investigated during the year under report but the spore material has been multiplied on six susceptible varieties for future use.

ii. Barley (*Hordeum vulgare* L.)

5. Covered smut, *Ustilago hordei* (Pers.) Lagerh.—Experiments with barley smut using six different seed treatments, in connection with the co-operative experiments of the I.C.A.R., were conducted at Karnal. Unfortunately the seed did not have enough of natural infection and as the plan of the experiment precluded the artificial infection of the seed, that was not done. The results obtained were very unsatisfactory.

iii. Jowar (*Sorghum vulgare* Pers.)

6. Long smut, *Tolyposporium ehrenbergii* (Kuehn) Pat.—This smut was brought into culture and added to the Indian Type Culture Collection of Fungi.

It is proposed to undertake experiments to determine the mode of transmission of the disease, using that culture in the forthcoming season.

iv. Pigeon Pea (*Cajanus cajan* (L.) Millsp.

7 Wilt, *Fusarium udum* Butler.—Pot Experiments. Twenty-eight varieties of pigeon peas were tested to see their reaction to the pathogen. Twelve of these were new accessions, the rest being the progeny of the varieties which had been tested before and which had shown some degree of resistance to wilt. IP 80 proved to be an immune variety while IP 41 and Hybrid 5 (D419-2-4) were up to five per cent susceptible. The rest were all highly susceptible to the disease.

Field tests.—Eight varieties were tested under field conditions in a wilt plot. IP 80 was four per cent susceptible while C. 15, A126-4-1 and Thadgani 1-4-7 were up to seven per cent susceptible. IP 41 showed 12 per cent susceptibility, the rest being highly susceptible to wilt.

8. Pigeon pea canker *Diplodia cajani* Ray Chaudhury.—This disease appeared in an epidemic form in some of the varieties, especially those from Jamaica. Later in the season the disease became manifest in the other varieties in a virulent form. Detailed observations have been recorded and further work on this disease is contemplated, if it is found to be widely prevalent in the pigeon pea growing areas in Northern India.

9. Collar-rot, *Pythium aphanidermatum* (Eds.) Fitzp.—Experiments with *Pythium aphanidermatum* (chilli isolation) were conducted in pots. In one set of experiments, the fungus was mixed with the soil at the time of sowing the seed and in another set, it was applied to the base of the seedlings ten days after they had emerged. None of the plants was infected and conclusive results have not been obtained.

v. Gram (*Cicer arietinum* L.)

10. Foot-rot and Wilt.—Isolations from 'wilted' gram plants were made on a large scale from collections made in U.P., Punjab, N.W.F.P., Gwalior and Bihar. The following fungi were isolated: *Fusarium* spp., *Operculella padwickii, Rhizoctonia solani* and *Rhizoctonia bataticola.* Several so-called 'wilted' plants did not appear to have been invaded by any organism, for none was found either in the sections when they were examined under the microscope or when they were incubated on nutrient media. The gram disease designated by the simple term 'wilt' appears to be very complex and as yet not clearly understood and unless the exact and precise etiology of the disease is known, it may not be possible to effectively control it. Experiments will be laid out in the coming season to see if the symptoms-picture presented by the disease produced by each of the above organisms, singly, differs; a key will be devised, if possible, to identify the disease in a precise manner in the fields.

vi. Potatoes (*Solanum tuberosum* L.)

11. Late blight, *Phytophthora infestans* (Mont.) de Bary.—Late blight was not present in Simla during the year under report and for want of the inoculum, resistance trials with different varieties of potatoes could not be undertaken.

12. Resistance of potato tubers to rotting by *Fusarium solani* (Mart) App. and Wr.—Tubers of 40 varieties of potatoes were tested to see if any among them possessed resistance to attack by *Fusarium solani* which causes a severe

tuber-rot. Four varieties, viz. cult. 296, 394, Aya Papa and M 09 did not take infection even after a month of exposure to attack by the fungus under optimum conditions of infection while five varieties, viz., cult. 230, Hyb. 2, 9, 11, 14 and J07 showed only five per cent infection. The rest were highly susceptible to attack.

13. Enzymes of *Fusarium solani*.—Work on the enzymes produced by *Fusarium solani*, was continued. As inoculation experiments with unknown potato varieties last year failed to give definite results, this year only those varieties were used whose reaction to *F. solani* was definitely known, viz. Cultures 256, 296, 304 and 394 and Aya Papa of I.E.B's. collections. Cul. 256 has been found to be consistently highly susceptible while the others have proved highly resistant, in the last three years' varietal resistance tests. Tubers of these five varieties were inoculated, after surface sterilization, by the plug method of Grainger and Horne. Eight weeks after they were inoculated the rot was found to be negligible in all the four resistant varieties, whereas in the fifth variety practically the whole lot of tubers had rotted.

A fairly active exo-enzyme of pectinase type was obtained from tubers of Cul. 256 inoculated with *F. solani*. A reduction takes place in the activity of this enzyme by diluting it with water or with the potato juice of the resistant Cul. 296 or of a susceptible variety. As yet no definite conclusions can be drawn from these experiments.

14. Virus diseases of potatoes.—*Solanum Virus* 3 (*Potato virus* A) was recovered from *"Phulwa"* and *"Darjeeling Red Round"*. Its identity was established by the reactions it produced on the differential hosts. The virus lost its activity at a dilution of 1 : 100 and it was rendered innocuous if kept for 36 hours at room temperature. Its thermal death point was found to be between 50-55°C. Evidence based on the reactions produced on differential hosts has been secured to show the presence of Solanum Virus 1 and 2 in mixture in varieties "President", "Up-to-date" and "Epicure".

15. Seed Potato certification.—The potato crop in five localities in Kumaon and Chakrata Hills and four in Simla hills at elevations between 5 to 7 thousand feet above sea level, was inspected. The negligible type of mosaic was predominant and its incidence was rather high in both the areas whereas the incidence of severe types of mosaic, leaf-roll and early blight was not so high. Examination of the potato crop for disease incidence in certain selected localities in the plains of Bihar, United Provinces, Punjab and Bengal where so far comparatively low disease incidence had been indicated, during observations in the previous years, showed that the incidence of Negligible types of mosaic was very high in all the commonly cultivated varieties. Severe types of mosaic were also present but their incidence was low. Early blight was observed in the plains' crop in all the four provinces. Aphid-infestation was common in Bihar, United Provinces and Bengal. Apparently virus free selections of "Phulwa", "Gola", "Darjeeling Red Round" and "Majestic" were grown at the Potato Station at Kufri (Simla Hills). Apparently healthy material of "Darjeeling Red Round" and "Majestic" and of a local variety, "Numbri" has been obtained. Other selections had to be discarded for they showed the disease under Kufri conditions where masking occurs least. Virus free "Darjeeling Red Round" tubers were again tested for freedom from disease and found to be quite healthy. A few such tubers have been sown at Kufri in an isolated plot to multiply the material under field conditions.

16. Potato seed multiplication.—Multiplication of partially disease free seed potatoes in connection with "Grow More Food" campaign was started during the year. The first crop was planted in October on 21.6 acres and the second in January on 16 acres, at Karnal. The second crop proved a failure for want of irrigation water. The first crop was examined four times. Plants showing mild mosaic, severe mosaic, necroses and leaf-roll were rogued out. Yield of 1861 maunds was obtained from the first crop. This material has been stored in cold store at Meerut partly for distribution to the provinces and partly for use as seed at Karnal in the next year.

vii. Tomatoes (*Lycopersicum esculentum* Mill.)

17. Virus diseases.—A virus causing stunting and smalling of leaves of tomato plants was isolated; its reactions on differential hosts and its properties are under study, with a view to identify it. The study of leaf-roll virus of tomato plants was continued. The variety "Sutton's Early Market" was under careful observation to determine the incidence of different virus diseases on it. The incidence of the disease was 100 per cent, leaf-roll and necrosis alone being responsible for 79 per cent and 97 per cent reduction in yield. None of the tomato varieties appeared to possess resistance to virus diseases. Late sowing of tomatoes had appreciably less disease but this affected the yield. This loss, however, could be remedied by close planting.

viii. Cucurbits

18. Virus diseases.—Melon mosaic was found to be seed transmitted. A sensitive and weak strain of Cucumis Virus I was recovered from red-gourd (Cucurbita maxima Duch.). Its properties and reactions on differential hosts were studied.

ix. Sugarcane (*Saccharum officinarum* L.)

19. Bed-rot, *Colletotrichum falcatum* Went.—The epidemic is reported to be completely under control in U.P. and Bihar. Work done during the year has once again proved that considerable transmission can take place through infected soil, irrigation water and the nodal regions of the cane; the pathogen has been found to survive in fallow land for about six months. One hundred and twenty varieties were tested to see their reaction to the fungus using all the four methods of infection, viz. infected soil, irrigation water, nodal infection and the plug method. Co. 205 proved to be fairly resistant while the rest were susceptible. Co. 386, 391, 538, Cok 3, and Cok. 25 proved to be susceptible when the plug method was used but moderately resistant when other methods were tried.

20. Physiologic races of *Colletotrichum falcatum*.—Forty-eight isolates of the fungus from affected canes of different varieties obtained from widely separated localities were tested on nine differential cane varieties. There does not seem to be any parasitic specificity in the isolates, though they manifested different degrees of virulence. Generally speaking, light coloured and highly sporing isolates were more virulent than dark-coloured and less sporing isolates.

21. Smut, *Ustilago scitaminea* Sydow.—Varietal resistance test was carried out with 120 varieties of which 58 were fairly resistant, 33 moderately susceptible and 29 highly susceptible. Most of the smut whips appeared in the months of May and June.

Paddy (*Oryza sativa* L.)

22. *Helminthosporium* disease of rice.—Three hundred and ninety growths from various samples were examined this year to determine which particular fungi are present in the diseased plants. *Helminthosporium* was present in 79 and *Curvularia* in 118 growths. Spores of 35 representative samples of *Helminthosporium* and 25 of *Curvularia* were measured. In 32 cases the measurements of the spores agreed with those of *Helminthosporium oryzae* Breda de Haan but the measurements in three other cases, one of which came from Sind and two from Orissa, were slightly smaller.

II. INDUSTRIAL MYCOLOGY

23. Not much work was done in this section on this subject. The Ordnance department desired to know how long a beer-yeast culture would remain viable in sealed ampules that are sent to forward areas for beer production for the troops. Experiments have shown that when the ampules are stored at a temperature of 30 or 35°C, they remain viable for three months only but when they are stored at a temperature of 20°C, they remain viable for eight months.

24. Fungi attacking textile materials and other military equipment.

Help was given to the Mycological Assistant from the Ordnance Laboratories Cawnpore, in identifying the fungi attacking textile materials and other military equipment.

III. TAXONOMY

25. Rusts.—A rust on *Stereospermum suaveolens* was found to belong to an undescribed genus; it was named *Mehtamyces.* Another rust on *Heterophragma roxburghii* was also found to belong to an undescribed genus and the genus was named *Santapauella.* The Indian species, described and undescribed, of *Ravenelia* were carefully studied. Fourteen species are now recorded for India of which six are proposed as new species, three are new records for India and one has been given a new name. The description of *Ravenelia indica,* the type species of the genius, had become confused due to misdetermination by Long, Arthur and others. With the help of Miss. E. M. Wakefield, this has been now carefully re-described from the type specimen which is in the Herbarium, Kew. Indian collections of *Uromyces,* especially those that are available in the *Herb. Crypt. Ind. Orient.* were re-examined and redetermined wherever necessary.

26. Smuts.—The following species have been proposed as new:

Cintractia fimbristylicola, Sphacelotheca apludae, Sphacelotheca cypericola, Tilletia ahmadiana, Doassansia hygraphilae and *Pericladium tiliaceorum.* The following have been proposed as new combinations: *Sphacelotheca aristidae-cyananthae* (Bref.), *Sphacelotheca isoilematis* (Syd. and Butler), *Sphacelotheca inayati* (Syd. and Butler). The following new records of smuts have been made: *Cintractia leioderma, Cintractia inclusa, Sorosporium kuwanoanum.* The spores of *Tilletia tumefaciens* were germinated for the first time. Germination of the spores of *Neovossia horrida* was obtained and it was found that it formed 80 or more sporidia, which do not fuse. Spores of *Ustilago burkillii* from a recent collection were germinated and it was discovered that the fungus belonged to the genus *Ustilaginoidea* and not to *Ustilago.* The combination

Ustilaginoidea burkillii has therefore been proposed. *Entyloma eugeniarum*, was found to be the immature stroma of a phyllachoroid fungus and was excluded from the smuts.

27. Miscellaneous.—Indian collections of *Phyllosticta* and *Leptosphaeria* were critically re-examined and monographs on them are in preparation.

IV. ADVISORY

28. Thirty seven requests for identification of cultures were received and complied with. Forty six specimens of diseased plants were received with a request that the disease be diagnosed. Twenty-five requests for references to literature, for descriptions of fungi etc. were also received and disposed of.

V. INDIAN TYPE CULTURE COLLECTION OF FUNGI

29. The Collection.—The Indian Type Culture Collection of Fungi, started as a scheme of the I.C.A.R., was taken over as a part of the Mycology Section from April 1, 1945. The collection consisted of 88 Phycomycetes, 191 Ascomycetes, 90 Basidiomycetes and 304 Fungi Imperfecti. Of the 191 Ascomycetes, 54 are yeasts and of 304 Fungi Imperfecti, 153 are species of *Fusarium*. The collection was maintained in triplicate at 16-19°C on Potato Dextrose agar, Oatmeal agar, Czapek agar or Malt agar, according to the needs of the particular fungi. The number of cultures obtained from abroad was 49. One hundred and ninety two cultures were supplied to correspondents in India and four to a scientist in China. There was a keen demand for cultures of *Penicillium notatum*, *Aspergillus* spp. and *T rulopsis utilis*. High penicillin yielding cultures of *Penicillium notatum* were specially obtained from the U.S.A. for this purpose. A list of the cultures available in the Type Culture Collection is in preparation and it is hoped to publish it as soon as possible.

VI. HERBARIUM.

30. Three hundred and forty two specimens were added to the Herbarium during the year. Many of these new accessions are type specimens or authentic specimens obtained from abroad. Mr. C. G, Hansford kindly sent 121 specimens of Ugenda fungi, several of them having been described by himself. Specimens of fungi were sent to 17 persons either for class use or for investigation. The accessions to the Herbarium for the past twenty years have not been extensive and there is not enough material of Indian fungi for distribution abroad for purposes of exchange. It is hoped to remedy this and establish exchange relations with some important Herbaria in Europe and North America. Exsiccata sets of *Reliquae Farlowianae* and of *Fungi Dakotensis* have already been promised in exchange.

VII. PROGRAMME FOR THE YEAR 1945-1947

I. *Plant Pathological Investigations*

i. Physiologic specialisation and modes of transmission of some cereal smuts (loose smut, flag smut and bunt of wheat, long and head smuts of jowar, other smuts).

ii. Studies in antibiosis and bacteriostatic and fungistatic substances with special reference to plant pathogens.

iii. Studies in fungicides on a laboratory scale.

iv. Study of suitable spray and dusting machinery.

v. Testing the disease resistance of crops evolved at the Imperial Agricultural Research Institute.

vi. Potato diseases: Viruses; selection of virus free material; tuber indexing; certification; multiplication of disease-free seed-tubers; early and late blight; potato storage rots.

vii. Tomato virus diseases.

viii. Sugarcane diseases with special reference to parasitic specialisation in the red-rot organism.

ix. Miscellaneous diseases.

II. *Mycological Investigations*

i. Taxanomy of fungi with special reference to rusts, smuts and the genus *Fusarium*.

ii. Maintaining the Indian Type Culture Collection of Fungi.

iii. Advisory work on mycological problems; identification of fungi received from the Provinces and States.

III. *Miscellaneous.*

i. Maintaining a Host-Index of Fungi.

ii. Preparation of Card-indexes of species of genera represented in India

iii. Maintaining an up-to-date card-index of literature of plant pathology and mycology.

iv. Training of post-graduate and other students.

REPORT OF THE IMPERIAL ENTOMOLOGIST

(Mr. P. V. Isaac, I.A.S.)

I. REPORT ON INVESTIGATIONS

1. *Insect vectors of virus diseases.*—(i) Tobacco leaf-curl.—The leaf-curl virus disease and its vector, white-fly, were commonly observed on a number of plants at Delhi. Some plants of a weed, *Sida rhombifolia*, of chillies, and *papaya* infected with A-type of tobacco virus showed symptoms of attack, the first two showed symptoms after 2-5 weeks and the third one after 9-10 months.

Spraying experiments were conducted near Jhansi for controlling white-fly on tobacco crop, the insecticide used was fish oil rosin soap in the proportion of 1 oz. in 1 gallon of water. The incidence of the pest was 5.4% as against 6.9% of the control plot when spraying started, but after 6 sprayings the incidence was 33.3% and 78.8% respectively.

(ii) Survey of sucking type of insects of other economic crops.—A survey of the sucking type of insect fauna on some important crops revealed a number of interesting insects, the more important of which were *Empoasca devastans* Dist. on cotton; *Creontiadea pallidifer* (Wlk.) on brinjal, safflower, pea and lucerne; *Campylomma livida* Reut. on jowar and maize; *Lygaeus pandurus* Scop. on grape vine and *Citrus* spp. *Myzus persicae* Sulz. on tobacco and tomato; *Aphis gosspyii* Glover on cotton and tomato; *A. laburni* Kalt, on cowpea and chillies; *Rhopalosiphum pseudobrassicae* (Davis) on *Brassica* spp.; *Urentius echinus* Dist. on brinjal; *Nysius inconspicuous* Dist. on tobacco pods and *Diaphornia citri* Kuw. on *Citrus* spp.

2. *Insect Population Studies.*—The Scheme for developing the line of research known as Insect population has been in progress for the fourth year. The following two were the main lines of work:—

(i) Development and standardisation of technique of population study,

(ii) Collection of data on population fluctuations of spotted bollworm.

The flaws in the study of percentage incidence described in literature under a variety of other terms such as 'number of insects per leaf and number of insects per unit area of leaf surface' have been pointed out. These methods are worse than even the recording of 'percentage incidence' because the scale used in the latter case involves only one variable factor—the *number* of valuable material, whereas the scale used in other cases involves two variables, namely *number* and *size* of leaves. Thus the best method so far known for recording pest incidence is the recording of population per unit area of land on which that crop is grown. The highest population during the season was 15,000 per acre and it was appreciably lower than that of previous years—the highest population per acre in 1941-42 was 23,000, in 1942-43 it was 20,000 and in 1943-44 it was 22,000.

Efforts were made to perfect the idea of Biograph and Biometer, reported briefly in previous year. With these instruments, in their perfect form, it is hoped that the duration of any stage or of full life-cycle under any range of

temperatures can be found out by merely counting a number of cells. A biometer has been drawn on a celluloid sheet to estimate the pupal period of *Earias fabia* and it is based on the following equation:—

$$Y = 5e^{-0.001106\ (97.288-t)^2}.$$

wherein t = temperature and $y = \frac{36.52}{P}$ when P is the pupal period of *Earias fabia* at temperature t°F. The horizontal lines representing developmental index (y) are drawn at intervals of 0.2 whereas the vertical lines representing time are drawn as in all thermograph charts at intervals of 2 hours. By means of this biometer when superimposed over thermograph records the pupal period of *E. fabia* under the temperature conditions existing during that period has been calculated. A comparison of these estimated pupal periods with actual pupal period observed during these months in field insectory has given fairly encouraging results.

The collection of data for the long range experiments on population fluctuation of spotted bollworm has been continued as in previous years. The three main items of work have been (a) field census, (b) field rearing and (c) meteorological observations within the cotton field.

3. *Pests of Stored food-stuffs.*—(i) Pests of Jowar.—Disinfection of pests of Jowar by Sun-heat treatment during dry summer months showed that the treatment was effective in heaps upto 1 inch thick on 'pucca'' floor and ½ inch thick on 'katcha' floor when exposed for 15 minutes and the temperature of the heap was 131°F. or above. A number of non-poisonous chemicals were tried as preservatives. D.D.T. and 666 were tried as dusts at the rate of 1|5,000 and 1|10,000 after diluting with chalk and mixed with grain against 5 stored grain pests. Complete mortality was obtained in 3 days time in all cases except with grubs of 'khapra' which did not die even after 17 days exposure. Carbon bisulphide was tried as a fumigant in different dozes and its effectiveness was found to vary with the temperature and humidity prevailing as also the duration of exposure. At higher temperature stored product pests were killed in shorter time than at lower temperatures.

(ii) Pests of dry fruits.—No extensive work was done due to transfer of staff.

(iii) Pests of stored pulses.—Some collections were made of the pests. *Bruchus analis* was found in 'moong', 'motth' and 'masoor'. As no staff was appointed in this Scheme work was held in abeyance.

4. *Survey of Icerya purchasi.*—This pest was observed for the first time in Chingleput, Chittoor and Ananthapur districts of Madras Presidency. It was also recorded for the first time from some localities of Madura and Salem districts. The pest invaded all these places through the agency of seedlings of *Casuarina equisetifolia* imported from infested areas. The pest has restricted distribution on citrus plants; it has been found doing serious damage only at Kodaikanal in Madura district but is found in small numbers at other localities in Madura district and at Bangalore.

Seven new host plants of the pest were found during the year. These are *Acacia elata, Acanthosperum hispudulum, Buxus sempervirens, Phyllanthus reticulatus, Plumbago zeylanica, Sopubea delphinifolia* and *Tephrosia vogelii* Three predators of the pest found, have been identified. Five other species of *Icerya* were collected and their distribution and host plants recorded.

The survey of San Jose Scale *Quadraspidiotus perniciosus* was continued along with *Icerya purchasi*. In all the localities examined for the latter pest, San Jose Scale was found only in Nilgiri and Shevaroy hills.

5. *Biological Control of pests of sugarcane.*—Liberations of *Trichogramma* parasite against sugarcane borers were made at three sub-stations. At Setabganj (Bengal) there was no initial parasitization of root borer, but in August the parasitization in the colonised block was 21.85% as against 5.5% in the control blocks and in October the respective figures were 28.68% and nil. There was no initial parasitization of stem borer, but in August the parasitization was 21.63% in the colonised blocks against 1.5% in the control blocks, and in October the respective figures were 36.58% and 27.7%. The average yield from the colonised blocks was 806.2 maunds against 635.2 maunds from the control blocks. At Cuttack the parasitization of stem borer during August was 57.3% in colonised plots as against 16.5% in control plots. The average yield was 320.5 maunds in the control plots, 249.7 maunds in six liberation plots (plots affected by floods and hence low yield) and 412.35 maunds in 12 liberation plots. In Sehore (Bhopal) in the 1944-45 experiments in July, the average egg parasitization of *A. sticticraspis* in the colonised plots was 9.68% against 19.76% in the control plots but in September the respective figures were 10.75% and 3.87%. In December, the parasitization came down to 5.0% and nil respectively. Before harvest, the egg parasitization was nil in all the plots. Change of ownership of the sugarcane fields and attacks of Striga pest in certain fields only made tonnage results useless for comparison. The station was closed down on 1-4-45.

The biology of *Stenobracon deesae*, braconid ecto-parasite of top, stem and root borers of sugarcane, was studied. Similar studies were made of an endo-parasite, *Apanteles flavipes*, of stem borers of sugarcane. Observations on the life-histories of *Nimboa basipunctata* and *Brumus suturalis*, predators of *Pyrilla* were also made. Observations made on *Trichogramma minutum* show that a maximum of 30 eggs were parasitized at 25°C. and 90% relative humidity and that the adults lived for a maximum period of 7 days when fed on 10% sucrose solution, while unfed adults lived for 2.5 days.

Experiments carried out at Karnal to conserve *Pyrilla* egg parasite showed that such plots gave an increased yield. Observations made on the occurrence of these parasites showed that the degree of parasitization varied from 7.4% in November to 23.42 in February. Mass rearing of *Trichogramma* continued thoughout the year and 30.5 million parasites were bred. Mass rearing of *Microbracon gelechiae*, a parasite of potato tuber moth got from Canada, was under progress; 300—400 parasites are now being bred daily.

6. *Termites and their control.*—A thorough survey was made of the Institute area in New Delhi for termite species. 121 collections were made and it was observed that *Cyclotermes obesus*, with its three closely allied varieties, were the commonest species here. Workers were found under cow-dung, dry grass etc., but living plants were not attacked. A female laid a cluster of 23 eggs on the 6th day after emergence which hatched two weeks later. In another case, a month after caging the pair, 49 nymphs and 36 eggs were found. Five mounds of the species were excavated and all types and stages were collected.

Other species collected were (i) *Microtermes anandi*, which attacks cow-dung and wooden structures in contact with soil, also freshly planted sugarcane setts; (ii) *Microtermes obesi* which is found in houses; (iii) *Microcerotermes*

heimi, a rare species, has been recorded for the first time; and (iv) *Eremitermes paradoxalis* collected from holes in soil under dry grass and cow-dung.

7. *Insecticides and fumigants.*—The insecticidal properties of opium and its various extracts and tobacco were studied in the laboratory. Opium and opium marc (a waste product left after the extraction of pure opium) were tried as stomach poisons against larvae of *Euproctis lunata* and *Bombyx mori*, but gave negative results. As contact insecticide, a 2% solution of opium marc had no injurious effect on larvae of *B. mori* and 20% solution caused 64.5% mortality. Dilute acetic acid extract of opium marc showed marked insecticidal value, a 5% solution yielding 85% mortality suspension of crude opium in water proved strongly toxic giving 92% kill at a strength of 0.2%. Almost similar results were obtained from experiments on *Bagrada picta* adults. A 5% solution of acetic acid extract of opium marc and 0.2% suspension of crude opium brought about 91.9% and 83.5% mortality respectively.

Samples of 42 varieties of tobacco were obtained from the Imperial Economic Botanist at two stages of development, and each sample divided into (i) leaves and (ii) stems and branches, with a view to find their nicotine contents and insecticidal properties. The nicotine estimations were carried out by the Organic Chemist while decoctions of each sample prepared according to the standard formula of soap, tobacco and water in the proportion of 1:4:40 and diluted 5 times, were tested on *Bombyx mori* larvae. Preliminary results of chemical and biological tests carried out so far indicate that a sample containing highest nicotine content (1.99%) produced the highest mortality (80%) and a sample having lowest nicotine content (0.59%) gave the lowest mortality (13.3%).

8. *Control of house-flies.*—The control of house-flies by various methods was carried out at the Institute throughout the year. Burying dung in pits under three thin layers of wet earth was found effective in preventing fly breeding.

9. *Insect Pests of potato.*—Observations on the life-cycle of apterous and alate forms of *Myzus persicae* were made. It breeds on potato from September to December. The developmental period from egg to adult for apterous form was 9 to 11 days and for alate 13 to 14 days. Longevity of apterous one was 18 days, producing 22 to 24 young ones and that of alate was 21 days, producing 20 to 21 young ones.

10. *Observations on Indian insects of economic importance.*—(a) Record of insect pests of crops.—Thorough surveys of the insects associated with agricultural crops, orchards and stored grains and their parasites were conducted in the neighbourhood of Delhi throughout the year. Of a large number of insects, the occurrence of life-history of about 250 insects were recorded.

The following insects appeared in a pest form on the estate of the Imperial Agricultural Research Institute.—*Scirpophaga nivella* on sugarcane; *Chilo zonellus* on maize, jowar and bajri; *Utetheisa pulchella* and *Laspeyresia pseudonectis* on Sann-hemp; *Taeniothrips distalis, Adisura atkinsoni, Agromyza obtusa* on arhar; *Laphygma exigua* on peas; *Earias fabia, E. insulana, Platyedra gossypiella*, and *Dysdercus cingulatus* on cotton; *Eublemma olivacea, Selepa docilis, Phycita clientella* and *leucinodes orbonalis* on brinjal; *Agrotis* sp. on tomato; *Rhopalosiphum psuedobrassicae* and *Bagrada picta* on cruciferous crops; *Dacus* sp., *Aulacophora foveicollis, Mylabris pustulata, Epilachna*

28-*punctata*, *E. dodecastigma* and *Sphenarches caffer* on cucurbits; *Euproctis lunata*, *Achaea janata* and *Dichocrocis punctiferalis* on castor plant; *Antigastra catalaunalis* on Sesamum; *Macrosiphum solidaginis* and *Acanthiophilus helianthi*. Besides these, *Amsacta moorei* on safflower, *Myllocerus maculosus* and *M. laetivirens* were found on a number of field crops. *Bagrada picta* appeared in a pest form in March and did considerable amount of damage to brassica crops at the Institute for about two months. For the first time it was found damaging sugarcane seedlings in a plot near brassica crop. The population of the pest fell considerably after May.

(b) Watch over insects likely to assume pest status.—*Earias cupreoviridis*, which is a servious pest of cotton in China but so far confined to some wild weeds in parts of India, was found to be fairly common on *Sida cardifolia* at Delhi. The insect entered hibernation in October in the pupal stage; moths emerged from the hibernating pupae after 6-8 months from March to May. It has been determined that the insect does not hibernate if reared at a high temperature of 30°C. during winter months. The life-cycle of this species and its behaviour is very much like the other two species of *Earias fabia* and *E. insulana*. It has been possible to successfully rear larvae of this species on cotton.

11. *Immature stages of Indian insects.*—The life-history of four interesting insects (i) *Cryptocephalous analis*, (ii) *Aegocera venulia*, (iii) *Hesperia galba* and (iv) *Lema* sp. which are very common during rainy season has been under study. Colour plates of these insects all of which feed on weeds have been prepared.

12. *Predators and parasites.*—Nearly 25 different parasites emerged from crop pests and over a dozen of predators were observed to feed on various pests. Some preliminary observations on the life-cycle of *Rodolia rufopilosa*, a predator of *Icerya purchasi* were made. The predator lays eggs in clusters and the total life-cycle completed in about 35 days. The number of nymphs and adults of *Myzus persicae*, a pest of potato, consumed by two predaceous flies, *Sphacrophoria javana* and *S. indiana*, was determined; it was found that the former consumed 238 individuals and the latter 200 during the course of Development.

13. *Taxonomic studies of insect groups of economic importance.*—Taxonomic studies of two families of parasitic Hymenoptera were made. A key of all the Indian genera of Braconidae was prepared.

14. *Imperial Pusa Collection.*—During the year under report 1247 named specimens belonging to 119 species of Coleoptera were registered and card catalogued. 225 species of insects were added to the collection and of these 41 species are new to the collection and two new to science. 64 species of common insects were donated to the Muslim University, Aligarh. Other donations included 14 species to Polytechnic Institute, Delhi, 14 species to Patna State and 1 to the Entomologist, Punjab. One parcel containing blown-up caterpillar of *Ephestia elutella* was received from the Bureau of Entomology, Washington (U.S.A.). A number of slides and preserved material of *Icerya purchasi* and *Quadraspidiotus perniciosus* were received from the Entomologist, Icerya purchasi Scheme, Coimbatore.

II. ADVISORY WORK

471 species of insects received from different parts of India were identified; 182 species of insects collected locally or from old Pusa Collection were also identified.

Nearly 50 enquiries received from different parts of the country were attended to and the requisite information supplied.

Control measures against several pests were undertaken in the Institute and even outside.

Over a dozen papers were examined in detail and reports regarding their suitability for publication were sent.

III. PROGRAMME OF WORK FOR THE TWO YEARS 1945-1947

1. *Discovery and control of Insect Vectors of the Virus Diseases of Indian crops.*—(i) Field-scale trials of sprays for the white-fly vector of tobacco leaf-curl disease will be made in co-operation with some Provincial Entomologists. (ii) Survey of the sucking type of insects of other economic crops particularly potato.
2. *Insect Population Studies.*—(i) Development and standardisation of technique of population study. (ii) Study of fluctuation of populations of spotted bollworms in relation to biotic and climatic factors, (as per programme approved by the Imperial Council of Agricultural Research).
3. *Pests of stored Food Stuff.*—(i) Experiments on the control of pests of Jowar will be continued and special attention will be paid to fumigation and inert dusts, (as per programme approved by the Imperial Council of Agricultural Research). (ii) Work on the control of dry fruit pests will be continued and special attention will be paid to the method of heat-sterilization of infested material. (iii) Pests of stored Pulses, similar to work on Jowar pests, (as per programme approved by the Imperial Council of Agricultural Research).
4. *Survey of Icerya purchasi.*—(As per programme approved by the Imperial Council of Agricultural Research).
5. *Biological Control of Pests of Sugarcane.*—Field trials with *Trichogramma* and detailed study of other potential natural enemies, (as per programme approved by the Indian Central Sugarcane Committee).
6. *Termites and their Control.*—Systematic and biological studies and control work of termites common in Delhi and Karnal.
7. *Insecticides and Fumigants.*—Trials of known insecticides like D.D.T. and 666 and fumigants and work on insecticides made from indigenous materials, particularly tobocco and waste products in opium manufacture.
8. Control of House-flies.—Field-scale trials of various methods.
9. *Insect Pests of Potato.*—Particular attention will be paid to the potato moth and the potato Jassids.
10. *General observations on Indian insects of economic importance.*—Keeping records of the seasonal occurrence and abundance of those insects found associated with crops. Vigilant watch for insects assuming or likely to assume pest status.

11. *Immature stages of Indian insects.*—Studies of immature stages of Indian insects and their mode of damaging crops.
12. *Predators and parasites.*—General biology of promising parasites and predators of insect pests of India.
13. *Taxonomic studies of insect groups of economic importance.*—Studies of Indian Parasitic Hymenoptera, Jassids, Capsids, Aphids, Coccids, Agromyzids, Tachnids, Muscids, and Coccinellids, (Work will be developed as per schools of research financed by the Imperial Council of Agricultural Research).

(xiv) *Imperial Pusa Collection.*—Building and maintenance of a reference collection of insects of India.

REPORT OF THE DIRECTOR, LOCUST CONTROL IN INDIA

(Hem Singh Pruthi)

I. GENERAL.

I continued to act as Head of the Locust Warning Organisation up to January, 1945 as Imperial Entomologist and thereafter as Director, Locust Control, in addition to my duties as Director, Imperial Agricultural Research Institute, throughout the year under report.

II. SWARM INVASION.

On account of the successful control measures adopted by the Indian anti-locust organisations in the monsoon breeding areas in 1944 as a result of which no swarms penetrated Mekran or crossed the Indian Frontiers in the west and no swarm was observed in any part of India after the 12th November 1943, it was hoped that the locust cycle had been brought to an end. Some of the foreign experts working in the neighbouring areas had also assured us that unlike in the previous years, in 1944 India would not be invaded from swarms from outside. This forecast, however, did not come true for though there was no breeding during early spring in the Persia or Oman, active breeding was in progress in Sudan, East Africa and coast of Red Sea throughout winter and spring and India was once again unexpectedly invaded by swarms during March and April, 1944.

As soil moisture conditions were favourable in Baluchistan they laid eggs over extensive areas in Mekran, Jhalawan, Kharan, Chagai, Lasbela and Chaman areas. In Sind also breeding occurred in western parts, viz., Dadu and Larkana districts. In Baluchistan control operations against hoppers were continued during May and concluded by the middle of June in all areas except in a few localities in Jhalawan (Kalat). In Sind hopper control was concluded by the end of May but some hoppers fledged into adults. The exotic immigration continued and in June 1944 Sind and Rajputana were invaded by numerous swarms (supplemented by escapes in Baluchistan) from the west. Fairly widespread rainfall had already commenced in N. W. India and the swarms readily congregated in the humid areas. Unlike 1943 the swarms did not cross into the United Provinces and only one small swarm reached Central India States and another reached Cutch State in the middle of July. Further eastward immigration continued during July and the invasion of the summer breeding areas in India fully developed during this month. Locust swarms were hovering almost all over the desert tracts of Sind-Rajputana and southern Punjab. Some of the swarms were very large and at a few localities in the Punjab and Sind they caused slight damage to young cotton.

1*st Monsoon Breeding.*—Early in July reports of egg-laying were received from some localities in almost all the States and hoppers were noted for the 1st time during this season in eastern Bikaner. In the 2nd fortnight of July swarm movements in Sind and Rajputana were fewer since the locusts were mostly laying eggs, which were noted over extensive areas particularly in Thar Parker District of Sind, north western parts of Jaisalm and south western districts of Bikaner State. Hoppers hatched several areas in all parts of Rajputana but were promptly destroyed at most localities. In the first fortnight of August extensive hopper infestation extended over vast tracts in the desert parts of

Sind, Bikaner, Jaisalmer and Jodhpur. Bahawalpur, Khairpur Mirs and Cutch States were also effected but to a less extent. Prompt and vigorous control measures were undertaken and a number of areas were cleared of hoppers in their early stages.

For the first time during this locust cycle there was monsoon breeding in Baluchistan and a small number of hopper bands were located in Awarun and Panjgur sectors of Mekran during the 2nd fortnight of August. These were promptly controlled.

Early in the 1st fortnight of September the 1st generation breeding was practically over in Sind and Rajputana and only a few bands were noted in some localities in Barmer district of Jodhpur State, north eastern Jaisalmer southern Bahawalpur and Tharparkar district in Sind. These were immediately destroyed. In some highly infested localities, particularly north-eastern parts of Jaisalmer and south-eastern parts of Khairpur State some hoppers escaped destruction and fledged into adults. As a result two or three small swarms developed.

2nd Monsoon Breeding.—There was a fair amount of rainfall in certain parts of Sind-Rajputana deserts during September but as the swarmlets flew mostly towards the west no breeding took place in Rajputana. The swarmlets, however, reached Dera Ghazi Khan and Muzaffargarh districts of Punjab, Dadu district in western Sind, Gandava area in Kachhi and Lasbela State during September. They laid eggs and gave rise to 2nd monsoon generation during October-November. On account of the paucity of swarms which were allowed to develop the 2nd generation was on a very small scale indeed. During this breeding also, the pest was destroyed mostly in hopper stage and no swarm developed in any part.

Fresh invasion of India in Spring, 1945.—No swarm movement was reported from any part of India in November and situation remained calm till the end of February. Extensive egglaying was however, reported in the eastern and Central Saudi Arabia during February and some swarms were reported moving south-east in Eastern Arabia. Swarms also developed from the earlier hatchings which escaped destruction from both coasts of the Red Sea during January and February. As forecasted, Baluchistan was invaded by swarms by the end of March. The 1st swarm was observed over Gar (near Persian border) on 28th moving from west to east.

Early Summer Breeding.—More swarms immigrated into Baluchistan from the west and via Afghanistan during April and laid eggs extensively in northern Baluchistan particularly in Kharan and Panjgur areas. Control operations were initiated and destruction was concluded at many places early in May before the hoppers could cross the III stage. There were practically no escapes,

A large number of the exotic swarms which entered Baluchistan in April migrated into the Punjab, N.W.F. Province and one swarm reached Meerut in United Provinces. In May egg-laying and hopper emergence were reported from several localities in the Punjab and N. W. F. Province and control operations were initiated. At the same time fresh groups of immigrant pink locusts continued to invade British Baluchistan.

III. LOCUST ACTIVITIES OUTSIDE INDIA.

International Locust Conference, Tehran, November 1944.—Dr. K. D. Baweja, Deputy Locust Entomologist, Karachi attended the conference from 7th—22nd November 1944 and gave detailed description of autumn-winter 1943-44 and monsoon 1944 breeding in India including Persian Mekran and showed the important role played by the Indian Anti-locust Organisation in successfully dealing with the infestation inspite of the meteorological attractions and not allowing any swarm to cross the Indian frontier in autumn of 1943 and 1944.

(2) *Middle East Anti-locust Conference, Cairo, January,* 1945.—Dr. K. D. Baweja, Deputy Locust Entomologist, Karachi was deputed to attend the conference. He explained the locust infestation, campaign organisation and control in India in 1943-44 with the help of maps etc., and showed how the Indian Anti-locust organisation was able to successfully combat and control all the infestation, both indigenous and foreign, within India and did not allow any swarm to escape to its neighbouring countries and further pointed out the cooperation and help rendered to the neighbouring countries by deputing parties of entomologists at India's expenses to carry out control work in Persian Mekran, Oman etc.

(3) *Indian Locust Delegation to East Arabia in* 1945.—Mr. S. G. Shabbir with three other locust entomologists carried out successful control work in Oman and Sharjah area in the spring and summer 1945.

APPENDIX I

Gazetted Staff of the Institute

Director	Dr. H. S. Pruthi	From 7-11-44
Joint Director	Dr. B. P. Pal	
Personal Assistant	Mr. A. M. Desai	

Agriculture.

Imperial Agriculturist	Mr. C. H. Parr	
Agricultural Experimentalist	Mr. R. D. Bose	The post is temporary.
Assistant Agriculturist	Dr. A. G. Riaz	
Statistician	Mr. P. V. Krishna Iyer.	
Farm Superintendent, Karnal	Mr. A. R. Khan	
Cattle Superintendent, New Delhi	Mr. N. P. Fernandez	
*Cattle Superintendent, Karnal	Mr. S. Zahiruddin (officiating).	*Mr. Zahiruddin officiated as Cattle Supdt., Karnal, till 23rd Dec., 44, when he was transferred on foreign service to Bahawalpur State and Mr. J. D. Sampat-Kumaran, the permanent incumbent of the post, who was on deputation on foreign service, took over charge of the post from 28-12-44.

Botany.

Imperial Economic Botanist	Dr. B. P. Pal	Dr. Pal left on deputation to China as a Botanist member of the Indian Agricultural Mission on 13th April, and returned to headquarters on the 20th June. Dr. S. Ramanujam held charge of the current duties of the post of Imperial Economic Botanist in addition to those of his own during this period.
Second Economic Botanist	Dr. S. Ramanujam	
Assistant Economic Botanist	Mr. R. B. Deshpande (Officiating).	
Second Assistant Economic Botanist	Dr. J. J. Chinoy	
Superintendent, Botanical sub-station, Pusa	Mr. S. M. Umar.	

Agricultural Chemistry & Soil Science.

Second Agricultural Chemist I/C.	Dr. S. V. Desai	(a) Posts are temporary.
Organic Chemist (a)	Dr. R. H. Siddiqui	
Soil Survey Officer (a)	Dr. S. P. Roy Choudhry.	
Assistant Agricultural Chemist	Dr. S. Das	

Agricultural Chemistry and Soil Science—contd.

Assistant Agric. Bacteriologist	Vacant temporarily	
2nd Asst. Agric. Bacteriologist	Mr. A. C. Ukil.	
Assistant Soil Survey Officer (a)	Dr. R. V. Tamhane	
Assistant Soil Survey Officer (a)	Mr. S. K. Mukerjee	
Assistant Soil Survey Officer (a)	Mr. K. V. S. Satyanarayana	

Entomology.

Imperial Entomologist	Dr. H. S. Pruthi	
	Mr. P. V. Issac (offg.)	From 1-2-45.
II Entomologist	Mr. P. V. Issac	
	Dr. Taskhir Ahmed (offg.)	From 1-2-45.
Biological Control Officer	Reseach Dr. E. S. Narayanan	Post is temporary.
Asstt. Entomologist	Mr. C. K. Samuel	
	Mr. H. Haroon Khan (Offg.)	From 1-5-45.
*Second Asstt. Entomologist	Dr. A. R. Ranjha (Offg.)	
Deputy Locust Entomologist, New Delhi.	Dr. T. Ahmed.	
	Dr. K. D. Baweja	From 1-3-45 (Post is temporary).
Deputy Locust Entomologist, Karachi.	Dr. K. D. Baweja	From 1-3-45 (Post is temporary).
	Mr. D. R. Bhatia	
Asstt. Locust Entomologist, New Delhi.	Dr. S. Mukerjee	
Asstt. Locust Entomologist, New Delhi.	Mr. D. R. Bhatia	(Upto 28-2-45).
	Mr. C. B. Mathur (Offg.)	Post is temporary.
Asstt. Locust Entomologist, Panjgur (Mekran)	Mr. Taqi Ahsan	Post is temporary.
Superintendent, Locust, Substation, Karachi	Mr. R. N. Batra (Offg.)	(upto 28-2-45).
Entomologist I|C. Icerya Purchasi Scheme	Dr. V. P. Rao.	

Mycology.

*Imperial Mycologist	Dr. G. Watts Padwick	*Dr. Padwick was on leave
Assistant, Mycologist	Dr. B. B. Mundkur	from 11-9-44 to 15-10-44 and

Mycology—contd.

2nd Asstt. Mycologist	Dr. B. L. Chona	proceeded on deputation to Bengal to take up appointment as Principal, Agric. Instt., Dacca on 23-10-44 after handing over charge to Dr. B. B. Mundkur, Asstt. Mycologist Mr. J. F. Dastur took over charge of the post of Imperial Mycologist from Dr. Mundkur on 31-3-45.
Asstt. Mycologist (Virus diseases) (b).	Dr. R. S. Vasudeva	
Seed Potato Production Officer (b).	Dr. R. S. Vasudeva from 26-5-45	

(b) Posts are temporary.

Sugarcane Breeding Station.

*Sugarcane Expert	Mr. N. L. Dutt	*Mr. Dutt continued to conduct the survey of Sugarcane Research in India, which was entrusted to him last year by the I.C.A.R. The work was completed by him in November, 1944.
Second Cane Breeding Officer	Dr. N. Parthasarathy	
Asstt. Sugarcane Expert	Mr. N. K. Krishnaswami	

APPENDIX II

Training of Students and Research Workers during 1944-45.

(a) *Awarded Postgraduate Diploma of the Institute.*

Botany.

Name	*Subject of Thesis.*
1. Parmanand Swarup Bhatnagar, M.Sc. (Luck.).	Cytogenetical studies in colchicine-Induced Polyploidy of crop plants (*Sesamum orientale* L.).
2. S. Murtaza Hasan, B.Sc. (Ag.), Agra, M.Sc. (Benares).	Crossability in Sesamum species and polyploids with special reference to pollen tube growth.
3. Clarence Arthur Gideon B.Ag., (Bombay).	Part I—Inbreeding in Brassica. A study of self-fertilization in certain species of the Genus Brassica.
4. Balabhadra Misra B.Sc. (Nagpur).	Part II—Vernalization in Mustard. A study in the vernalization of *Rai.* (B. *juncea Coss*). The Experimental Production of Chimeras.
5. Amar Nath Khanna, B.Sc. (Ag.) Agra, M.Sc. (Benares).	Part I—Physiological studies in diploid and autotetraploid chillies (*Capsicum annum L.*).
	Part II—Crossability between Plants with different chromosome numbers in chilli (*Capsicum annum L.*).
	Part III—Self-sterility and crossability in diploid and tetraploid *Toria* (*Brassica campestris L.* var. *Toria*).
6. Ranjit Singh, B.Sc. (Ag.), (Punjab)	The effect of environment upon the yield and quality of wheat.

Entomology.

7. Girdharilal Naraindas Bhatia, B.Ag. (Bombay).	Part I—The life history and bionomics of *Goryphus nusei* (Cameron), an Ichneumonid parasite of spotted boll-worms of cotton.
	Part II—Our present knowledge of hymenopterous parasites of major pests of cotton in India—A review.
8. Rattan Lal, M.Sc., (Punjab).	Part I—A. The Biology and Bionomics of some sucking insects of potato plant.
	B. Sucking insects observed on Potato plants at different times at Delhi in 1943-44.
	Part II—Our present knowledge of potato insects of the world—A review.

Mycology and Plant Pathology.

9. Jagadisha Chandra Raghunath Mhatre, B.Sc. (Bombay).	Part I—The genus Gymnosporangium in India. Part II—The Synchytria of India.
	Part III—Chilli disease caused by *Choanethora cucurbitarum*, (Bark. and Rev.) Thaxter.

(a) *Awarded Postgraduate Diploma of the Institute*—contd.

Name	*Subject of Thesis.*
10. C. S. Ramamurthy, B.Sc., (Hons.) Madras.	Part I—The Genus *Pharagaidium* in India. Part II—Mode of transmission of the Karnal Bunt of wheat.

Agricultural Chsmistry and Soil Science.

11. Nayani Veera Mohana Rao, B.Sc., (Andhra), M.Sc., (Benares)	"Influence of varying ratios of exchangeable Calcium to Sodium on Soil Properties and Plant Growth.
12. Hasan Luqman, B.Sc., (Agra.), M.Sc., (Benares).	Some aspects of Sugarcane Breeding in India.
13. Gursham Singh, B.Sc., (Punjab) M.Sc., (Benares).	Part I—Sugarcane and its cultivation. Part II—Breeding in Sugarcane-with special reference to the methods adopted at Coimbatore. Part III—Morphological inheritance of some Co. canes. Part IV—The order of the shoot arrowing (flowering) in a clump and its interpretation on the effect of arrowing on sugarcane crop. Part V—Arrowing (Blooming) in sugarcane in relation to the emergence of the shoots above ground. Part VI—A comparative study of the anatomy of flowering and non-flowering shoots in sugarcane. Part VII—Some preliminary studies on the physiology of water-shoots or gaurmandizers. Part VIII—Sett-root studies of some Co. canes.

(b) Awarded Post-graduate Certificate in Agriculture.

1. Ajit Singh Bhondi (Punjab).

(c) *Post-graduates under training during the year.*

Agriculture.

1. Luxmi Narain Raizada.	(Punjab).
2. Mukhdum Nazir Ahmad.	(Punjab).
3. Sukhraj.	(Punjab).
4. Banta Singh Dhillon.	(Punjab).
5. Abdul Ghafur Khan.	(Punjab).
6. Vaddi Rama Rao.	(Madras).
7. Sibta Mehdi Naqir.	(U.P.).
8. Shyam Lal Bhatnagar.	(Udapur State).
9. Chaturbhuj Narain Singhel.	(Alwar State).

Botany.

10. Narendralal Dhawan.	(C.P.).
11. S. Basharat Ali Shah.	(Punjab).
12. V. Ramamurthi.	(Madras).
13. Jugdish Chandra Varma.	(U.P.).
14. Choudhury Mohd. Sharif Sardar Khan.	(Sind).
15. Yogendra Mohan Upadhyaya.	(Jaora State).
16. Shyam Narain Sharma.	(Udapur State).

Entomology.

17. Parkash Lal Ranjhen.	(N.W.F.P.).
18. Abdul Mannan.	(N.W.F.P.).
19. Yogendra Prasad.	(Bihar).
20. Daljit Singh Sarkaria.	(Patiala State).
21. Mohammad Mohsin.	(Bhopal State).

Mycology.

22. Said Ahmad Malik.	(N.W.F.P.).
23. Saeed Mohd. Khan Kheshgi.	(U.P.).
24. Har Kishan Saksena.	(U.P.).
25. Naseer Khalid.	(Kashmir).

Chemistry.

26. Khub Gianchand Tejwani.	(Sind).

Sugarcane Breeding.

27. Obaidullah Jan.	(N.W.F.P.).
28. Om Prakash Agarwal.	(U.P.).

(d) *Students admitted for short courses of training.*

1. Dr. G. Venkatachalam (Orissa).	Botany	6 months.
2. Dr. R. S. Choudhury (Benares).	Chemistry	2 months.
3. T. N. Dar (Rampur State).	Dairy	2 months.

(e) Students admitted for training as Virus Inspectors in connection with the scheme for production of comparatively disease-free potatoes.

1. Ishwari Prasad (Bihar).
2. Jai Narain Misra (Bihar).
3. S. C. Chowdhary (Assam).
4. Sharif Ahmad Khan (U.P).
5. Yashpal Chandra (U.P.).
6. Mohd. Imdadul Haq Khan (Bengal).

(f) Honorary Research Workers.

Name	*Subject of Research.*
1. Dr. S. P. Aiyar (Burma).	Base exchange in relation to soil fertility.
2. Murtaza Hasan (Hyderabad).	Crossability in Sesamum species and polyploids with special reference to pollen tube growth.
3. Govindaswamy (Madras).	Cytogenetic and Morphological studies of inter-specific and inter-generic hybrids of sugarcane.
4. P. S. Bhatnagar (U.P.).	Cycogenetical studies in wheat.

APPENDIX III

List of papers published during 1944-45:—

Ahmad, T. and Ghulam Ullah. — The development and fecundity of *Melcha nursei*, Indian J. Ent., Vol. VI, 1945.

Ahmed, M. — The morphology and biology of *Bhogas* Testaceus, Indian J. Ent., Vol. V, 1944.

Biswas, S.C. — Fuel gas. Indian Farming Vol. No. 3 March, 1945.

Bose, M. — Bionomic and life-history of *Myllocorus laetiverens Indian J. Ent.*, Vol. V, 1944.

Chinoy, J. J. 1945. — A simple micro-macerator for plant analysis Curr. Sci., 14: 102-103.

Chona, B.L. — Sugarcane Mosaic and its control. Indian Farming, V, 4, 1944.

Das, S. —

1. The manurial value of different phosphates in calcareous soils. Indian Journal of Agri. Sci. Vol. 14, Part IV, Aug., 1944.
2. A simple method for estimating carbonates in soils. *Ibid.* Vol. 14, Part V, October, 1944.
3. Availability of superphosphate with depth of its placement in calcareous soils. *Ibid* Vol. 15, Part I, Feb., 1945.
4. The combined action of organic matter and phosphatic fertilizers in soil. *Ibid* Vol. 15, Part I, Feb., 1945.
5. Apricot cake as a nitrogenous manure. *Ibid* Vol. 15, Part I., February, 1945.
6. Relative availability of different natural and artificial phosphates in calcareous soils. *Ibid*, Vol. 15, Part III, June, 1945.
7. Summary of paper No. 5 above was published in Indian Farming Vol. 6, No. 4, April, 1945.

Datta, S.C. — On the bacteriophage of root nodule organisms, Indian Jour. of Agri. Sci, Vol. XIV Pt. IV. August, 1944.

Desai S.V. and S.C. Biswas. — Manure and gas production by Anaerobic Fermentation of organic wastes. Indian Farming Vol. VI, No. 2 Feb., 45.

Desai S.V. and Rao, W.V.B.S. — A new method for determining the soil manurial needs. Proc. 32nd Indian Science Congress P. 31 (1945).

Desai S.V., Vyas N.D. & Batra, K.C. — A new method of soil notations for comparative studies of soil characteristics. Current Sci. 1944, p. 99-100.

Deshpande, R.B. . Inheritance of bunchy habit in chilli (*Capsicum annum L.*) Indian J. Genet. and Plant Breed, 4 : 1 : 54.

Dutt, N.L. . Report on the Survey of Sugarcane Research in India. Printed by Manager, Government of India Press, New Delhi, 1945.

Dutt, N.L. . 'New Co. Canes' 1944 Batch, Indian Farming Vol. V, No. 9, 1944, p. 420.

Dutt, N L. . 'New Co. canes' 1945 Batch, Indian Farming Vol.-VI. No. 4, 1945, p. 176.

Haroon Khan, M. . The relative abundance of *E. fabia* and *E. insulana* in various parts, Indian J. Ent., Vol. VI, 1945.

Haroon Khan, M. *et al.* . The crossing of *E. fabia* and *E. insulana* Vol. VI, 1945. *Indian J. Ent.*

Isaac, P.V. . Insect pests of dehydrated meat and fish, 'Indian Farming' Vol. V, No. 12, 1944.

Jandu, A.S. . Biological notes on butterflies of Delhi, Indian J. Ent., Vol. V, 1944.

Khan, A.R. and Bhatnagar, N.P. . Cowpea Varieties and Culture. *Indian Farming* Vol. VI, No. 5, 1945, 212-213.

Krishna Iyer, P.V. . The Distribution of the Mean of Samples from a Rectangular Population. *Curr. Sci.* 14, 1945, 18-19.

Krishna Iyer, P.V. and Rao, P.S. . A Preliminary Investigation into the Influence of the Fundamental Dimensions of a plough on Draw-bar-pull, Depth and Resistance Per Unit Area. Ind. Jour. Agric. Sci. 14, 1944, 240-244.

Mani, M.S. . Studies on Indian Itonidodae, *Indian J. Ent.*, Vol. V, 1944.

Mani, M.S. . Description of some fossil Arthropoda from India, *Indian J. Ent.*, Vol. VI, 1945.

Mani, M.S. & Ahmed, M. . Studies on Indian Parasitic Hymenoptera, *Indian J. Ent.*, Vol. V, 1944.

Mohan Singh. . Fumigation and heat sterilization of insect pests. Indian Farming, Vol. V, No. 3, 1944.

Moorthy, B.R. and Viswanath B. . Spectroscopic analysis of soil colour. Proc. Ind. Acad. Sci., A., Vol. No. 20, P. 311, 1944.

Mundkur, B.B. . Manoranjan Mitra, 1895-1942. Phytopathology XXXV, pp. 2-3, 1945.

Padwick, G.W. . Notes on Indian Fungi. III. Mycol. Pap. Imperial Mycol. Inst. No. 12, 1945.

Padwick, G.W. and Azmatullah Khan. Notes on Indian Fungi. II. Mycol. Pap. Imperial Mycol. Inst. No. 10, 1944.

Pal, B. P. and *Pushkarnath.* . 1944. Self and cross incompatibility in some diploid species of *Solanum*. *Curr. Sci.*, 13: 235-6.

Pal, B. P. and *Viswa Nath, B.* . 1944. The accumulation and movement of nicotine in reciprocal grafts between tobacco and tomato plants. Proc. Indian Acad. Sci. 20(B): 79-87.

Pal, B. P. 1944. . The Pusa Wheats: The wheat breeding work of the Imperial Agricultural Research Institute. Empire J. Exptl. Agri. 12: 61-73.

Pal, B. P. and *Deshmukh, M. J.* . 1944. Potato 'tops' 'eyes' as seed Curr. Sci. 13: 309-11.

Pal, B. P. and *Narayana Rao, T.* . 1944. Does accilimatized cigarette tobacco seed deteriorate. Indian Farming 5: 516-17.

Pal, B. P., Ramanujam, S. and *Narayana Rao, T.* 1945. . An improved variety of flue-cured tobacco. Ind. Farming, 6: 154-155.

Pal, B. P. and *Ramanujam, S.* 1944. . Plant breeding and genetics at the Imperial Agricultural Research Institute, New Delhi, Indian J. Genet. and Plant Breed 4: 43-53.

Parr, C.H. and Bose, R.D. . Phosphatic Manuring of Legumes, Part II, *Indian Farming,* 6 1945, 201-208.

Parr, C.H. . 1. Work on Cattle Improvement at the Imperial Agricultural Research Institute, New Delhi, *Indian Farming,* 6, 1945, 222.

2. The Utilisation of Surplus River Water during the Monsoon in Crop Production, Curr. Sci., 1945.

Pradhan, S. . Rate of insect-development under variable temperature of the field, *Proc. National Inst. Sci.,* Vol. XI, No. 2, 1945.

Pradhan, S. and Menon, M.G.R. . Distribution and sampling of spotted bollworm of cotton, *Proc. National Inst.* Sci., Vol. XI, No. 2, 1945.

Pruthi, H.S. . Leaf-curl disease of tobacco in India, 'Indian Farming', Vol. V, No. 5, 1944.

Pruthi, H.S. . War against Locusts in India, '*Current Science* XIII, 1944.

Ramanujam, S. 1944. . Genetical research as applied to plant breeding in post war India. Curr. Sci., 13: 63-65.

Rao, P.S. . Comparative Studies of Some Indian Plough with Dynamometer. *Ind. Jour. Agric. Sci.* 14, 1944, 398-433.

Rao, W.V.B.S. . Standardisation of the method of estimating nitrite with Gniess Ilosvay's reagent. Jour. of Ind. Chem. Soc. 21: 51 (1944).

Rao, W.V.B.S. Desai, S.V. and Reddi, M.K. . Studies on the method of estimating total bacterial counts in soil, Ind. Jour. Agric. Sci. June, 1945.

Siddiqui, R.H., and Ali S.M. .	1. Exam. of S. Phipsoni Pt. I. *Ibid*, 1944, 131.
	2. Chem. exam. of S. phipsoni, Pt. II. *Ibid*, 1944, 134.
Siddiqui, R.H. and Basha, S.K. .	A note on O-xytropis thomsoni. *Ibid.*, 1944-83.
Siddiqui, R.H. and Mathur, M.L. .	Effect of coagulants on the quality of rubber Part II, *Ibid*, 1944, 215.
Siddiqui, R.H., Usmani, R.H. and Ali, S.M. .	Studies in the pyridine series, Pt. IV. *Ibid*, 1944, 245.
Siddiqui, R.H., Usmani, R.H., and Ali, S.M. .	Strychnine and Brucine Pt. VI. *Ibid*, 1944, 295.
Siddiqui, R. H., and Warsi, S.A. .	Chem. Exam. of the fatty matter from the seeds of S. pseudocapsicum. Ind. J. of Phar, 1944, 68.